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## Mechanical and Engineering Section.

*(Stated meeting held Thursday, November 19, 1908.)*

## Natural and Artificial Conservation of Water Power For Electrical Purposes.

BY EDWARD R. TAYLOR.

The call of the Governors' Conference by President Roosevelt last May was the inauguration of a development of resources more stupendous than ever before contemplated by any people upon the face of the earth, and it is destined to be of value to our people beyond any present power of computation. Startling facts were arrayed showing the rapid and near-by exhaustion of resources which when once used can never be replaced, and emphasis was placed upon the necessity of utilizing other resources now going to waste which might delay the exhaustion of the unreplacable.

Of all our resources capable of meeting these exigencies, no other begins to compare with the systematic and perfect development of our water power, and no other so abundantly helps navi-

gation and commerce without which the marketing of our products, manufactured and otherwise, cannot adequately be performed. Our railroads have admitted their inability to do the work required of them, and even the expenditure of hundreds of millions of dollars would not make them capable of doing what in the nearby future would be required of them, if unaided by water navigation.

I deem myself happy therefore to have been invited by the Franklin Institute to address you to-night on the "Natural and Artificial Conservation of Water Power for Electrical Purposes." These last two words are important, for electricity has made possible the development of water power in one place and its utilization in another, a fact so familiar that I do not need to dwell upon it at this time.

In the conservation of water for power purposes, forests are of great value. They prevent the wearing away of soil so essential to all vegetable growth and by the decay of the fallen leaves add to fertility, and make possible the absorption and retention for a long time the water that would otherwise run quickly away. They also retard the melting of snow in the Spring and thus conserve water for later use. But while the ground is frozen it cannot absorb any more water and unless there are lakes, ponds or reservoirs to receive this water it passes rapidly to the sea, carrying many times devastation in its way, so much so that the annual damage by floods in the United States alone is computed at not less than $100,000,000.

Forestry alone is incapable of meeting the exigency and must be supported by water storage to be really effective. This water storage should begin in the farmers' brook.

Mr. W. A. Ritter wrote a fine description of Mr. Chas. Call's power plant, published in the Ohio Farmer of July 25th, 1908.

This picture of Mr. Chas. Call's dam, which impounds the water of a brook which you can easily step across, is an illustration of such a development. Two months from the time Mr. George H. Lodge, of Cuyahoga Falls, his son-in-law, started with him to build that dam, they were lighting Mr. Call's house and other buildings by electricity produced by that babbling brook. It is simply an earth dam with a concrete spillway with some stones the farm could well spare for the water to fall upon.

A little brook, yet that great passage way thirty-two feet long

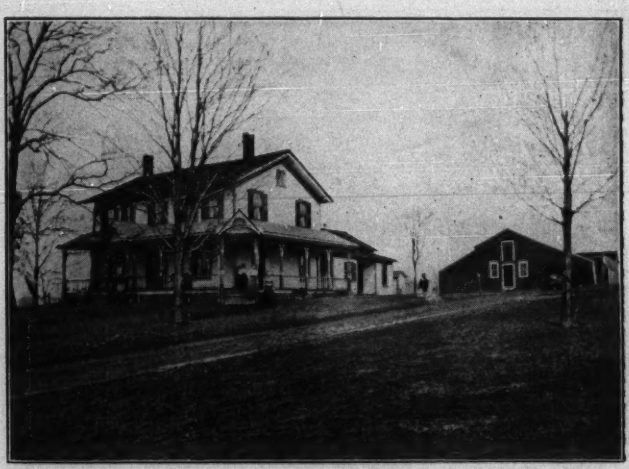
and say two feet high was filled within five inches of its top last Spring, and when I visited his home a few weeks ago, I found Mr. Call had added eighteen inches to the height of his spillway and was scraping the earth in to increase the height of the rest of the dam. He said it was surprising how fast they could fill the dam up in that way. In such work the earth should always be higher than the concrete and the concrete high enough so that the water can never get over its sides, no matter how heavy the flow of water coming down. With these precautions earth dams

Dam of Mr. Charles Call. From "Ohio Farmer."

when properly constructed, especially if they have a diaphragm of concrete deep down and running their whole length and planted with willows are in many places the cheapest and best dams. This dam is over 300 feet long and cost about $400 to construct. The total equipment about $1200. A $60 chandalier shows its elaborateness. When the dam is filled with water it covers about four acres and affords pleasure for boating, swimming and fishing. Under the dam at this point is a sewer pipe eighteen inches in diameter connecting with a rectangular box open at the top and at one side and passing to the lower side of the dam. By lifting

the gates on the front part of this box the pond was emptied of its water to do the work shown and a large quantity of fish revealed. As a matter of fact such a pond properly stocked with fish is capable of yielding more value per acre than the ordinary farm will produce by cultivation.

The power house is shown at the left, in which is a six-horse-power water wheel and five kilowatt dynamo. This furnishes light and runs some small machines. The wheel is started and stopped by a wire running to the house and attached by very in-



House of Mr. Charles Call. From "Ohio Farmer."

genious contrivance to the gate of the water wheel. Mr. Lodge deserves great credit for the ingenuity shown in the installation of this plant. The discharge pipe for overflow and for emptying the pond is shown in this picture, and in front of it in the willows is shown the little brook hardly more than two feet across at that point. Mr. Call says there are seven or eight places on that little stream where other farmers can do as well or better.

It was nice to note the generous credit Mr. Call gave the young men, Messrs. Lodge and Ritter, for the accomplishment of this work, and right here I may say, I believe there is a large field for

competent young men to assist farmers in such developments. There are literally thousands of such opportunities all through the land, and farmers should embrace them without delay. It will mean the aggregate storing of immense quantities of flood waters in the feeders of large streams and enhance the value of such farms from 25% to 50%, to say nothing of the luxury of electric lights and electricity applied to plowing, seeding, reaping, mowing, haying, cultivating and other outside operations, performed with the aid of the electric automobile applied to farm uses.

Barns of Mr. Charles Call. From "Ohio Farmer."

A starter is shown in the haying scene exhibited, and in the same house, washing, ironing, cooking and a multitude of little things where heat is required, as also in many cases heating the house in winter time.

Mr. John T. McDonald, of Delhi, N. Y., has another similar and larger development, being about twenty-five horse power, and in addition to lighting his house and barns he has a shop with saws, planers and special machinery, and finds it very handy on rainy days to spend them in comfort and pleasure with his men in

doing useful work by machinery. This is finely described by Prof. H. L. Bailey, in the Outlook for August 25th, 1906.*

He has a model farm in the upper Delaware Valley, says he can develop as much again power as he has now, cuts ice from his

pond for himself and neighbors (as does Mr. Call previously referred to). There a.e other such developments in the country to which I need not now refer.

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*On returning I visited the farm of Mr. McDonald. There were once eighty-nine saw mills on that little brook, and his is now the only water power development on the stream. It is about 1400 feet above sea level, and the whole upper country of the Delaware and Susquehanna present the most abundant possibilities of lake storage. See map of Banff country, which illustrates it very well, though it is more mountainous than the Delaware country.

These are small beginnings, but they are the forecasts of lots of others, all of which means the conservation of water and the equalization of summer flow.

Nowhere can a like expenditure of money count so much for the comfort and betterment of home life on the farm, and power conditions lower down on the stream.

In early times even small water powers determined the location of places. For years Cleveland, Ohio, was a hamlet near Newburg, the start of the latter being determined by a small water power that is now abandoned.

In many cases ideal sites for power were inadequately developed by the first users, who had power enough for their purposes, and did not, or could not, purchase sufficient land to compass the solution of an ideal site.

At Kent, Ohio, is shown a dam constructed on ideal plans and in an ideal situation, with rock bottom and sides, originally constructed by the State for canal purposes, its use for power being secondary, and no advantage was taken of the opportunity to buy cheap land above for storage purposes. Now the land would cost a great deal, besides a railroad has possession of one of its banks. A beautiful piece of stone channel cutting is shown in making place for the railroad. But for this condition and the high price of land above, this would be an admirable site for larger development and storage of water. The gorge is shown above the dam with its regular sides.

This location is famous for the historic leap of Captain Brady, who in fleeing from the Indians jumped the chasm as they were almost upon him. It was an almost superhuman thing to do, but he was successful and succeeding in hiding himself among logs and lily pads of Brady Lake, while the Indians had to pass around to a ford higher up the stream. Though walking over his head upon the logs they failed to find him.

Cuyahoga Falls also illustrates another inadequate early development of an admirable site. At a suitable time overflow land could have been purchased at a moderate price and a large storage secured between Kent and Cuyahoga Falls. As it was the fall was great and gave them all, and more than all, the power they required.

The next picture shows the three upper dams in succession and the arrangement of flumes and buildings is a fair illustration of

marred natural beauty that make us rejoice that more artistic and beautiful developments are being made to-day. Other parts of the gorge below are very beautiful.

Some years ago a race was started in the gorge to convey water to Akron, about four miles below, where there is a fine head and large water power development. The Salt River Power Canal illustrates the modern construction of such a power canal and shows the great value of concrete construction for such work. In all these there was no conservation of water in any proper sense, and is a fair illustration of the irregularity of river flow without storage reservoirs, and the Cuyahoga is like the majority of streams throughout the country, almost dry at times and surging bank full at other times, when it goes down in such quantity that it can be turned to no useful account, and often carries destruction in its way.

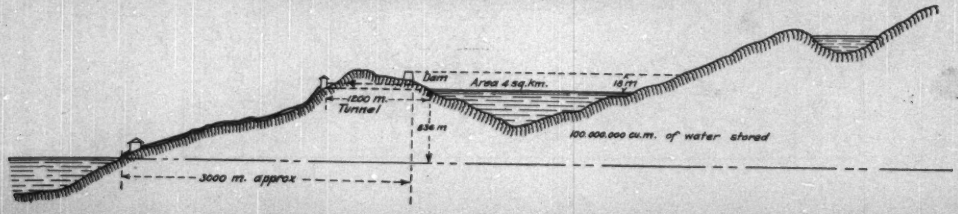
Look at the map of the United States showing the rivers. The lake regions of New York and New England, to a certain extent, conserve water and make more or less valuable water powers, but are by no means adequate and should be both enlarged and increased in numbers to do what is required of them. On the other hand such streams as the Delaware and the Susquehanna are threads of water without lakes, very low in summer and flooded every year with water that ought to be stored in the hills from whence they came. There is abundant opportunity.

The feeders of the Ohio are largely the same, throwing an aggregate of water into the Ohio, carrying damage and destruction all along their course. This can be saved by reservoirs in the Appalachians.

There is probably not a single year when the flood damage to Pittsburgh does not exceed $3,500,000, while in the summer boats are loaded with coal and held in the upper waters to be floated at flood down the river. How much better to reforest the hills and impound the water in the ravines and make the Ohio and many of its branches navigable the whole year through, at the same time saving from inundation millions of acres of immensely valuable lowlands of the Mississippi Valley, while lands very much less in value are used in the up-country to store this water, at the same time developing power that is valuable.

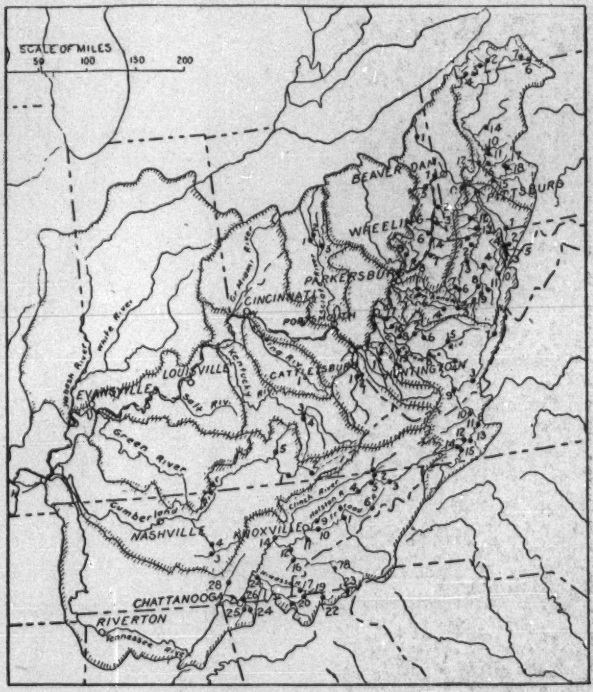
The place to hold water back is in the upper parts of the country where land is cheap. A hundred million dollars damage by

Ideal country in which to build dams, make large lakes and store water.




Ideal water power site in Norway. From "Electrochemical Industry."

flood every year is a high price to pay for our folly. Better pay a portion of that amount per year in making storage for water and reforesting suitable places and develop water power which, in addition to paying for the cost, will save millions of dollars per




Proposed water storage in the Appalachians. From "World's Work."

year in coal. Banff illustrates an ideal country for water storage.

Dr. Putnam, before the Governors' Conference, made clear that 30,000,000 horse power of water can comparatively cheaply be developed in the United States, while the development of 150,000,000 horse power could be practicably considered. When one reflects

that the useful application of one horse power of water per year is the equivalent to saving twelve tons of coal per year, we may well ponder as to the proper utilization of the immense power at our disposal.

As a rule land that is not very valuable may be used for storage purposes, and even if it is valuable, in some cases, would be more valuable for use in impounding water than the uses to which it is now put. Ravines abound and are better so used than not. The dam can be in many cases largely made of stones that

Doe River, Tenn. Ravines for storage and power.
From "Forestry and Irrigation."

now cumber the ground and the farms be the better for their removal.

The Oswego water shed is advantageously situated for such installations and there are literally thousands of farms where this water storage and power can be installed and with it may come the annual saving of thousands of tons of coal, at the same time relieving the finger lakes of much of the strain put upon them in the rainy season.

Many examples of such possibilities could be given, such as

Big Stream, which has its rise in Tyrone, in Schuyler County, at an altitude of about 1100 feet, passing through Yates County into Seneca Lake, through a good farming country, and having a fall of more than six hundred feet in the course of ten or twelve miles. Such a stream as this properly harnessed is capable of doing the ploughing, seeding and harvesting of the farms through which it passes.

Flint Creek, in Yates County, also offers possibilities more pretentious, and has in addition considerable lake storage possibilities that should certainly be investigated. There are several small dams already on this creek, that can without doubt be enlarged and turned to more useful account by means of dynamos.

Kashong Creek passes through a gulley above Bellona, where a large storage pond could be made and a fall of sixty to eighty feet obtained at Bellona, which could be developed to the great advantage of the town, where a twenty-foot head is now developed and runs a grist mill. These are simply spoken of as examples. There are hundreds of similar cases.

There are other respects in which this water shed is unique, in that there are multitudes of deep glens offering heads of from 100 to 300 or 400 feet, and above them gulleys of small value which could be dammed and large quantities of water stored.

One of the most noted of these is Watkins Glen. I speak of this with delicacy. Some people would say, "Would you blemish Watkins Glen with a water power?" I say, no, I would beautify it with a water power. The storage would be all above the Glen where people visit, and enough water could be allowed to pass in the summer over the cascades to be more than equal to the low water of summer, as it is now. There is very large room for ponds, and even lakes, in the upper part of this stream where very large quantities of water could be stored, and the power used at Watkins to very great advantage.

There is a similar Glen at Hammondsport. A power development in a similar glen at Ithaca was made several years ago and has been in successful operation ever since. The secret of making all of these glens successful producers of power is to secure abundant bondage at higher levels. This is probably possible in every one of them in every case with a rock bottom for the foundation of suitable dams.

Little Lake and Lamoke Lake, in Schuyler County, are at an

elevation of 387 feet above Lake Keuka, and only about two miles therefrom. Their outlet could be dammed at Bradford and their level raised and made into one lake seven or eight miles long and about one mile wide with a large power development at Keuka.

As the waters from these lakes now makes its way into the

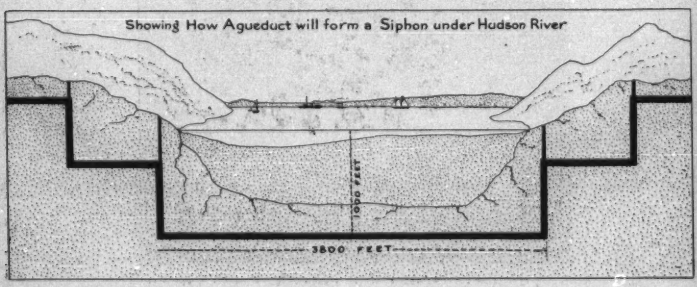
Pondage site above glen.

Site for dam above Glen. Taken n dry weather.

Chemung River, a tributary of the Susquehanna, its diversion to the Oswego water shed would have to be made a matter of Inter-State agreement. This raises a very important question, as there is often great advantage, as in this case, to be derived from diverting water from one water shed to another. Where for similar reasons the water can be used to better advantage. Here is a fall

of nearly 400 feet in the space of two miles with a fair supply of water, means a very large power, as 100 pounds per minute means the continuous development at this head of more than one horse power and savings of twelve tons of coal per year for each horse power.

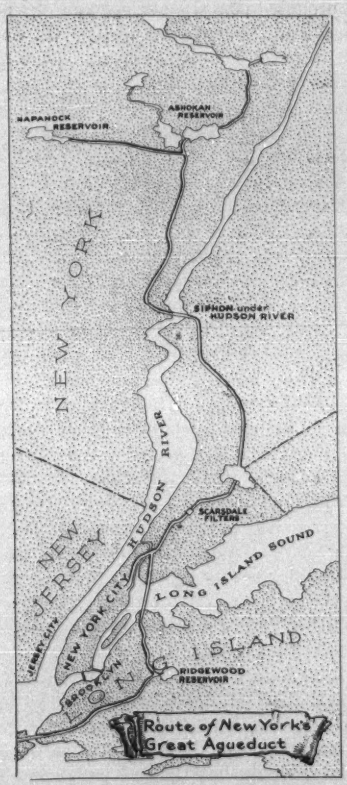
Making concrete aquaduct. New York City Watee Supply.




New York City is about to expend $165,000,000 in storage and conveyance of water from the Catskill Mountains, a distance of eighty-five miles.

This great enterprise includes a great syphon to convey the water under the bed of the Hudson River. There will be a fall

of 610 feet, at least 300 feet of which could be used for power purposes, with the possible development of nearly 35,000 horse power and the saving of 420,000 tons of coal per year. I am indebted to the *Popular Mechanics* for this illustration showing a




map and plan for syphon under the Hudson River and an aqueduct of concrete.

Notwithstanding a fall of more than 100 feet at Rochester, the water is so low in summer in the Genessee that less than

2000 horse power is available, when by proper storage 100,000 horse power would be available the year round at that one point.

It has been proposed to construct a dam at Portage and impound a large quantity of water above the gorge at that point. A map of the proposed lake is made showing the present position of railroad tracks and the position they would occupy when removed to make way for the improvement. This great undertaking is advocated by the New York State Water Supply Commission, and I am indebted to them for the map above referred to. They are also proposing to make a similar storage on the Sacandaga River, north of Albany, in the State of New York.

Four great storage reservoirs and one hundred and thirty-five feet fall of water utilized makes Niagara Falls the seat of power that it is to-day.

The Genessee River might offer the next best power in the State, but it has no important lakes and more than one hundred times as much water passes in flood as at its minimum flow.

Not so with the Oswego River, only about twenty-five times as much water goes through it at flood as at minimum flow.

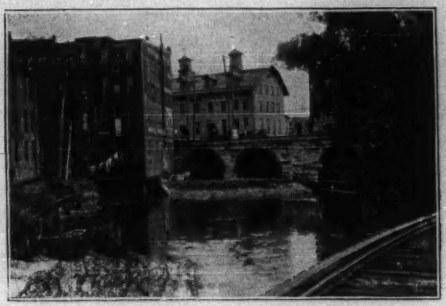
The storage capacity in what are known as the Finger Lakes of our State make the difference. These are natural reservoirs in a very small measure assisted by dams to retain much of the flood water, with the result that it is probably the more regular water power stream that has its rise in the State; yet under present circumstances it is more than usually pressing that we should ask if the present water storage capacity can be materially increased.

The raising of the dam of Canandaigua Lake would probably be attended with the least trouble and damage. The variation in Canandaigua Lake from highest to lowest water, as I understood, does not exceed five feet, and the spring run-off is always very heavy, and the summer very light.

The dam at Keuka Lake makes the possible difference of level of from six to eight feet from high to low, and there are sometimes as much as two or three feet of water goes to waste over this dam. To raise this dam a few feet and secure a larger supply of flood water, would be attended with some damage, but could be provided for by filling low places and other easements at Hammondsport, Branchport, Penn Yan, and some small places, including cottage sites. But this difficulty is not insurmountable. The dam at the foot of Seneca Lake, I understand, is in bad con-

dition and needs suitable repair to enable Seneca Lake to become the storage reservoir that it is capable of being.

Cayuga Lake is the most difficult to deal with of all the lakes of this system, as it is the lowest of them all. But on the other hand, on account of these very features, it could be made the most



State dam, Keuka Lake. Water low.
This controls the water flow.

Burnt over district, Lake suitable for storage. Level should be raised.
From "Forestry and Irrigation."

valuable of all these lakes for storage purposes, as it constitutes the bottom receptacle of nearly all of them.

This leads us to the question that has greatly troubled our ablest engineers, and I only dare to tread on this ground after them because of its transcendent importance.

I have no doubt but because of this sag the engineers have felt the necessity upon them to step the canal now building down in the vicinity of Newark and up again as it approaches the Rome level. This makes necessary the absorption of a portion of the water of the Oswego water shed for the locking of the canal at this lower level.

The level of the proposed Barge Canal, as it leaves Lake Erie, is 564 feet, and it locks down all the way from there to a point a little east of Rochester. Could the level of the canal from this point be maintained to get over the Rome level, which is 391 feet and 6 inches, the problem of a lock down canal all the way from Lake Erie to the Hudson could be solved.

I do not presume for a moment that all of these questions have not been carefully considered by those in charge of the canal work. But we are now up against conditions that have never before made possible the consideration of things in the large way that is absolutely forced upon us to-day.

The West is calling for the cheapest kind of transportation for its grain and other bulk goods to the Atlantic Ocean. The breaking of bulk where it can possibly be avoided is recognized as a very great disadvantage. A canal for navigation purposes alone only fulfills a part of its possible mission, especially a canal that could be made a lock down canal with the total fall of 564 feet to tide water.

If a ship canal coupled with a water power canal were made between Lake Erie and the Hudson River, the value of the water power alone would be a very large factor in paying for its enormous cost. It is to be borne in mind in considering such a great proposition, that when once done, as it ought to be done, it will be a continuous source of large income. We are therefore justified in putting the best thought we can conceive upon this important subject and ask ourselves, Is it worth while? Every ton of water per minute that could be made to pass through water wheels in such a canal to the Hudson River would mean the generation continuously of thirty horse power and the saving of 360 tons of coal per year.

A large development of water power could be made in the vicinity of Lockport, Rochester, Waterloo, Seneca Falls, and from Little Falls to the Hudson River, an enormous development of water power, there being some three hundred feet fall between

these points. We might be justified in such a work for the accomplishment of a great purpose.

Chicago, years ago, found itself in the mud and they assembled as one man and raised those great blocks of buildings and streets, and we have a new Chicago. These were necessities and were done because people had to do them.

The question arises, Is the construction of a ship and power canal from Lake Erie to the Hudson River of sufficient importance to justify the employment of modern means to raise Ithaca and Watkins to a higher and healthier level, and some of the very small places that might be in the way of such a development. These things accomplished the daming of Cayuga Lake opposite Cayuga would make a large storage reservoir of Cayuga Lake

A river on a rampage because it has no storage lakes.
A fair sample of nearly all the rivers in our country.

and enable the level of the canal to be such as to pass the Rome level. A dam across the foot of Cayuga Lake that should have a large spillway and empty the flood water of the watershed into Cayuga Lake would make a large power development possible at Cayuga and equalize the flow of the Oswego River, and thus conserve the flood water of this great and important watershed, and make available the same for the purposes of power and lockage of vessels.

The present Barge Canal is constructed only as a navigation canal, without reference to water power in this electrical age even for the towage of its own boats, and which can be used for that purpose only seven or eight months per year, while the power of a

ship and power canal could be used the whole year through with the production of values running into the hundreds of millions of dollars. It seems passing strange that so important a work should have been undertaken without the coördination of other interests quite as important as those of navigation. All of these interests should work in harmony for the highest possible development of all of our resources as a people.

From the Report to the Governor of the Advisory Board of Consulting Engineers from January 1st, 1907, to January 1st, 1908, page 21, paragraph 4, we take as follows:

"The Board did not feel justified in recommending a generating or transmission system which would allow of possible expansion of power uses for electric haulage or for the sale of surplus power by the State, holding that this was a matter not connected with the appropriation for the construction of water ways."

"The details of power generation for and application to lock mechanism is being given particular study and a set of tentative designs have been submitted to the State Engineers' Department for consideration."

It will be said by many that all this is out of the question. Galveston and Chicago are to-day greater cities than they could have been but for the great work that they have done.

Ithaca can, by modern hydraulic methods, be raised to a proper position, and concrete docks and breakwaters constructed, before which not only the pleasure steamers of Cayuga Lake shall land, but also the commerce of the world. We should not damage Ithaca, but better it beyond its most hopeful thought of the future. We should not damage the water power users of the Oswego watershed, but bless them with reliability of power such as they have never before known, and not have damage suits from them but money instead, for benefits received.

"Albany, Nov. 16.—Fulton Power Company Has Title to Bed of River, Court of Claims Holds in Big Barge Canal Action. State Loses First Phase of Suit for $3,428,028; May Multiply Canal's Cost Enormously. No Appeal Possible Until Award Fixing Damages has been Reached."

"The State Court of Claims to-day decided against the State in a motion to dismiss the claim of the Fulton Light, Heat and Power Company, of Fulton, Oswego County, for $3,428,028 for

the permanent appropriation for barge-canal purposes of land in Fulton and of the developed and undeveloped water power in the Oswego River there, together with an alleged depreciation in value of the electric light plant of the company."

The claim, which involves a test case on behalf of power concerns at various points whose water power is to be taken over for canal purposes, was before the court on the issue of the State's ownership of title to the bed of the river and the water rights which the companies are seeking to protect, and the claim has not been tried on the question of the amount of damages sustained by the concern. The decision of the Court of Claims undoubtedly later on will be carried to the Court of Appeals.

In refusing to dismiss the claim, the court holds, in an opinion written by Judge Rodenbeck, in which the other judges concur, that the claimant is the owner of the lands which are to be taken for barge canal purposes, which include the power site of the company at Fulton.

The court agrees with various contentions of law advanced for the claimant, but, under the opinion handed down, has reached no conclusion as to the extent of the riparian rights attaching to the land, which must be determined when the trial is resumed.

Until the case is fully closed, and an award fixing the amount of damages is reached, the State cannot review this determination of the Court of Claims in the higher courts.

The main points covered by the opinion are that a State patent bounded by a fresh water non-tidal stream carries title to the center of the stream; and that a private individual may acquire title by prescription in the bed of such a stream, even though the stream may be navigable.

The far-reaching effect of this decision, if it is sustained, in increasing the cost of the barge canal or other improvements to navigation in this State, cannot be overestimated.

There are a score of other sites like Fulton, at each of which there are a score or more of water power users who will file similar claims in like big amounts. It is understood that these water power users are acting somewhat in concert in furthering the prosecution of the claim now on trial.

Trial of the claim has brought out a notable array of attorneys in behalf of the power companies, headed by Prof. C. A. Collins,

former counsel to Governor Flower. The State was represented by Deputy Attorney-General George P. Decker."

We should make a State canal that should lock all the way down from Lake Erie to the Hudson and that should not be simply a navigation canal but a power canal as well, with its large power at several places already referred to along its course where the grains of the great West could be made into flour and numerous industries dependent upon bulk materials manufactured into goods of higher value, so that even the railroads would rejoice in elevating their tracks and running them alongside this great waterway as they see in prospect the millions of cars of high-class, well-paying freight that they shall be called upon to move from the manufacturers along its banks. Dockage in New York City would be relieved by docks wherever needed along such a canal.

This is not a time for war, but for the coördination of all the forces of the State, and the United States, for the production of a highway to the sea that shall not only carry the commerce of the world, but by its power, convert untold millions of property from a lower to a higher value.

The great State of New York must get out of a thimble and do things worthy of its name, the great "Empire State." But, as a matter of fact, the State of New York need not do this great work alone. The great West, with Chicago as its spokesman, and even financiering, will help in this work as only such people know how to do. Maybe Chicago business men would take the raising of Ithaca as their own responsibility.

Do these great things now, and when the coal mines of Pennsylvania are exhausted, and even long before, our successors shall rise up and call us blessed.

I do not belittle this great undertaking, but the large interests involved are so stupendous that it is necessary to do things wise enough and great enough to coördinate the whole.

In closing this address, I cannot do better than quote from an address by Mr. McClintock, an eminent engineer, and one of the Canal Commissioners, before business men of Rochester when it seemed certain that a barge instead of a ship and power canal would be built, and also a letter recently received by me from Mr. Lyman E. Cooley, one of Chicago's most eminent engineers, in connection with the drainage canal.

PART OF ADDRESS OF MR. M'CLINTOCK, CANAL COMMISSIONER.

"We demand that the plan adopted shall be one that will give the greatest benefit to the largest number of people. We have studied the surveys made for a ship canal by the way of Lake Ontario, and the various surveys for a barge canal; also the topographical survey of this portion of the State covering the canal which is now complete; also the history of the present canal, and we assert the force of the following propositions:

"1. A barge canal by the way of Lake Ontario would be more for the benefit of Canadian interests than New York.

"2. A barge canal through Rochester and Syracuse would be of no appreciable benefit to any interests in the State except a comparatively small contingent in Buffalo and New York.

"3. It is more than probable that as soon as this State is committed to the construction of a barge canal for 1000 ton barges, work will be begun upon a ship canal from Georgian Bay to Montreal which will give passageway for 8000 ton ships, and such a canal will be finished by the time of the completion of the barge canal.

"4. A ship canal 30 feet deep and 300 feet wide, taking a supply of water from Lake Erie and forming a great navigable river for 350 miles from that lake to the Hudson River is the only scheme that is worthy of consideration by this great State at this stage of its industrial development. Such a canal would be beyond the competition of railroads in the movement of freight. The commerce on it could not be controlled by any combination of ocean steamships or inland railroads, and it can be built so as to make possible the creation of permanent water power worth $500,000,000, distributed at various points clear across the State.

"Such a canal could be built without increasing the burden of taxation, and be made to pay its cost directly.

"We insist that before the people of this State are asked to vote upon the proposition to spend $75,000,000 to $100,000,000 on a barge canal, detailed studies and reports be made upon this project."

21 Quincy St., Chicago, Nov. 2, 1908.

*Mr. Edward R. Taylor, Penn Yan, N. Y.*

DEAR SIR:—I have yours of the 27th ult. inclosing copy of

your paper read before the Electrochemical Society, which I have read with pleasure. You are thinking along the right lines.

Mr. Geo. W. Rafter did much work in your State on this subject and made some valuable reports.

The project of carrying a supply of water from Lake Erie to the Hudson River was an original idea of Governeur Morris, and has been discussed with every change in the canal. The report of the International Commission, of which I was a member, Washington, 1897, submitted profiles of both the Mohawk and Champlain routes, and suggested the cutting out of the Rome summit to the level of Oneida Lake, and the Fort Edward summit to the level of Lake Champlain. These propositions were estimated by the Board of Engineers on Deep Waterways. See their report, 1901.

The West is in favor of the betterment of all water routes to the sea, but the majority of people look upon the barge canal as an improved toll gate for the special benefit of New York State. The West would not assist in asking the General Government for money for the barge canal, but would be very glad to help in securing the additional money which would be required above the cost of the barge canal to make a first-class ship canal. We want thirty feet and not twenty feet when we get ready to break through to the Atlantic.

We shall have a ship route to the Atlantic sooner or later, and so far as the West is concerned, it will go along the line of least resistance, for an outlet to the sea, in our minds, takes supremacy over any question of route.

Yours truly, LYMAN E. COOLEY.

Referring to Mr. Cooley and the drainage canal: The State of Illinois is about to extend this canal sixty miles, to be a part of "From the Lakes to the Gulf Ship Canal," and Chicago's interest is now centered therein, and it remains to be seen if our slow east has lost its grand opportunity.

It is interesting to note that the stone excavated in making the drainage canal has been found to be worth millions of dollars for concrete and other work. So it might be with a New York ship and power canal in the interest of good roads. Lots of stone, cheap power for crushing and cheap transportation for their use. May we do this great thing.

# History, Manufacture and Analysis of Maple Products.

By Albert P. Sy, Ph.D.

(*Concluded from vol. clxvi, p. 352.*)

## THE LEAD VALUE OF MAPLE PRODUCTS.

In the Hill and Mosher method, the result might be expressed as "acid value in terms of malic acid" of a maple product. Since in some cases it was found quite difficult to get satisfactory results, it was decided to modify it in such a manner as to determine the "lead" part instead of the acid radicals in the lead precipitate. The earliest preliminary experiments with this method gave these results, for "lead value":

*Sugars:*

| Description of sample. | Known to be: | Lead precipitated by 100 grams of sample "Lead value." |
|---|---|---|
| Carrier, No. 11866 | Pure maple | .331 |
| Ranke | Pure maple | .455 |
| Franklinville | Pure maple | .343 |
| Little Valley | Pure maple | .373 |
| Bryant | Pure maple | .386 |
| Cöoperative, No. 1 | Adulterated | .048 |
| Cöoperative, No. 2 | Adulterated | .046 |
| Cöoperative, No. 3 | Pure maple | .197 |
| Brown sugar (cane) | Cane sugar | .052 |
| Granulated sugar (cane) | Cane sugar | .006 |
| Maple sugar, made in Lab'y | Pure maple | .429 |
| Half cane, half maple | 50% maple | .213 |

*Sirups:*

| Description of sample. | Known to be: | "Lead value." |
|---|---|---|
| No. 10202 | Pure maple | .225 |
| 10204 | Adulterated | .048 |
| 12130 | Adulterated | .061 |
| 12221 | Pure maple | .208 |
| 10188 | Adulterated | .083 |
| 10201 | Adulterated | .033 |
| 12679 | Adulterated | .060 |

| | | |
|---|---|---|
| 10203 | Adulterated | .044 |
| 10306 | Pure maple | .320 |
| 13305 | Pure maple | .190 |
| 13306 | Adulterated | .005 |

The results were obtained by diluting 50 c.c. or 50 grams of a sample to about 200 c.c., boiling, adding about 20 c.c. saturated solution of lead acetate (neutral), settle, filter; the lead precipitate was then decomposed with aqua regia, $H_2SO_4$ added, diluted, alcohol added and the $PbSO_4$ determined as usual; from this the Pb was calculated. No special precautions as to dilution of sample, filtering and washing of precipitate, etc., were taken; yet the results without exception gave enormous differences between pure and adulterated samples. A preliminary note on this method appeared in the Journal of the Franklin Institute, July, 1906, p. 71.* A great deal of experimental work has been done since and the method is now presented in the form which gives very satisfactory results. Instead of subacetate of lead as used in most all other methods for producing a lead precipitate, the neutral lead acetate is used. The advantages of the neutral salt are—

(1) It does not undergo changes as quickly as the sub-salt.

(2) Its composition does not vary; the subacetate varies in composition, according to method of preparation, from $Pb(OH)C_2H_3O_2$ to $Pb_3O_2(C_2H_3O_2)_2$ and this is probably the main cause of the discrepancies noticed in other methods where the precipitate is weighed or the volume measured.

(3) The neutral salt does not precipitate caramel like the sub-salt.

(4) The neutral acetate is more soluble in water than the subacetates. At 20°C. 100 c.c. water dissolves 50 g. lead acetate, but only 5.5 g. of $(PbO)_2Pb(C_2H_3O_2)_2, H_2O$; the $(PbO)_3Pb(C_2H_3O)_2, H_2O$ is almost completely insoluble.†

After considerable experimental work it was found that much better results can be obtained by using the neutral instead of the subacetate of lead.‡ While it is possible to differentiate by this

*Several months after this appeared, Winton published his "Lead number" method (Jour. Am. Chem. Soc., Sept., 1906, p. 1205). He had developed his method independently, and read a description of it at a meeting of the American Chemical Society, June 28, 1906.

†Schmidt, Pharmaceutische Chemie, II, p. 384.

‡The use of natural acetate of lead was first suggested by Blyth (p. 110, "Foods, their Composition and Analysis"); it is also used in the Hill and Mosher method.

method between pure and adulterated products without special precautions as to dilution and washing, it was thought desirable to determine experimentally the best process for this method, so that different analysts could get concordant results on the same samples. The principal part of the lead precipitate being lead malate, this salt was prepared by adding an excess of a 10% solution of neutral lead acetate to a solution of malic acid; the precipitated lead malate was filtered, washed and dried between filter paper and finally in vacuum over $H_2SO_4$. An excess of the dry salt was put in distilled water and also in a 65% sirup and heated just to boiling, cooled to 20°C., and the lead determined in part of the clear filtrate; this lead was calculated to lead malate, $PbC_4H_4O_5$, $3H_2O$.

SOLUBILITY OF LEAD MALATE, $Pb\,C_4H_4O_5 \cdot 3H_2O$

| 100 c c at 20° | Dissolved head malate | Equivalent to Pb $SO_4$ | Equivalent to Pb |
|---|---|---|---|
| Water | 0.1547 | 0.1193 | 0.0814 |
| Sirup (65%) | 0.1701 | 0.1312 | 0.0895 |

This is a solubility which cannot be ignored in adding water to a sample for dilution or for dissolving, and also for washing the lead acetate precipitate, and makes it necessary that the same amount be used in each case. In the above experiment on solubility, lead malate was used. To obtain data as to what may be the solubility of lead precipitates from samples of pure maple products, the following determinations were made, using in each case the amount of water indicated for making the original solution of sample, and using in addition 100 c.c. for washing the lead precipitate:

| | Water used for solution | Lead precipitated. | Lead value. |
|---|---|---|---|
| Sugar A, 50 grams. | 150 c.c. | 0.270 | 0.540 |
| | 200 | 0.254 | 0.508 |
| | 250 | 0.234 | 0.468 |
| | 300 | 0.200 | 0.400 |
| Sugar B, 50 grams. | 150 | 0.385 | 0.770 |
| | 200 | 0.348 | 0.696 |

Besides indicating solubility, these results also show that, since the composition of the lead precipitate is different from different samples, its solubility is also different.

The solubility of lead malate in water, and therefore the lead precipitate in a sample, increases very much for temperature higher than 20°C., according to Partheil and Hübner.* It is necessary therefore to allow the sample to cool to 20°C. (or room temperature) before filtering off the lead precipitate. The washing also must be done with water at about 20°C.

(5) Basic lead acetates precipitate sugar, forming lead sucrates much more readily than the neutral salt. This would introduce an error in all methods, volumetric as well as gravimetric.

Occasionally it is desirable to have an analysis of a sample that has begun to spoil or ferment. In the early part of the work on this method the samples were diluted and precipitated without being first boiled, as was the practice in all the other methods. In some cases it was found that adulterated samples gave high results, producing as much lead precipitate as some pure samples. On the supposition that products of fermentation, especially $CO_2$, are the cause of this, the samples were boiled before adding the lead acetate; concordant results were obtained after this. The fact that no account is taken of the fermentation products, and that the samples are not boiled, accounts for irregular and unreliable results by other methods where the precipitation is made directly.

Determinations on samples before and after fermentation gave the following results:

| | Pb. ppted by 100 c c of sample "Lead value" | Vol. Pb. ppt. New method p. 123 | Wt. Pb. ppt. Canadian method | "Lead number" Winton |
|---|---|---|---|---|
| No. 41. Adulterated Sirup, fresh..... | .102 | 1.7 | 1.9 | |
| fermented 5 days... | .112 | 2.2 | | |
| fermented 10 days.. | .126 | 3.6 | 5.7 | |
| No. 37. Adulterated Sirup, fresh..... | | 1.3 | 1.38 | 0.26 |
| fermented 14 days.. | | 2.0 | 1.60 | 0.44 |
| No. 48. Adulterated Sirup, fresh..... | .020 | | Sirup No. 26 $\left(\begin{matrix}6.6\\8.9\end{matrix}\right)$ | |
| fermented 7 days.... | .035 | | | |

*Arch. Pharm., 241, p. 413.

At this rate of increase in values, some of these samples would soon give data corresponding to those of pure products.

The dilution of the sample with 200 c.c. water is necessary on account of the fact that lead malate is soluble in the acetic acid liberated by the reaction of the lead acetate. Experiments showed that a

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 c.c. of | 0.2% | solution | acetic acid | dissolves | 0.10 g | lead | malate. |
| " | 0.4% | " | " | " | " | 0.13 | " | " |
| " | 0.7% | " | " | " | " | 0.18 | " | " |
| " | 0.9% | " | " | " | " | 0.20 | " | " |

A maple product with a "lead value" of .200 would leave enough acetic acid in the solution to make it only 0.11%, if 200 c.c. of water are used. While this would not dissolve very much lead malate, yet it shows that it is necessary that the amount of water used should be specified, and should be the same in all cases.

These investigations finally led to adopting the "lead value" method as follows:

To 50 c.c. sirup or 50 g. sugar add 200 c.c. water; heat to boiling, add 20 c.c. neutral lead acetate (10% sol.), cover, and heat again to boiling; let stand until cold. Filter, wash with 100 c.c. water (about 20°C.). Transfer filter and precipitate to 400 c.c. beaker, add 15 c.c. $HNO_3$ and 10 c.c. HCl, cover and heat on asbestos plate or gauze, or hot plate; when filter is disintegrated, remove from flame, cool slightly and add 10 c.c. $H_2SO_4$; heat to fumes to expel all $HNO_3$; if blackening does not clear in a few minutes, add 5 c.c. more of $HNO_3$ after cooling a little, and continue heating to fumes. Cool, add 50 c.c. water, boil, cool and add 100 c.c. of alcohol; let stand six hours or over night; filter and determine weight of $PbSO_4$, preferably by filtering on tared asbestos Gooch crucible, wash with alcohol and finally with ether, dry, ignite at low red heat for about two minutes. The weight of $PbSO_4$ multiplied by 1.36586 ($2 \times 0.68293$ factor for $PbSO_4$) gives the weight of *Pb* precipitated by 100 c.c. or 100 grams of sample, or the *"lead value,"* which should not be less than 0.250 for a pure maple product. It is usually over 0.300.

The following *"lead values"* were obtained on samples of sugar known to be pure:

PURE MAPLE SUGARS.

| Sample No. | "Lead value." | |
|---|---|---|
| 1 | .580 | |
| 2 | .384 | |
| 3 | .762 | |
| 4 | .468 | |
| 5 | .470 | |
| 6 | .376 | (min.) |
| 7 | .648 | |
| 8 | 1.024 | (max.) |
| 9 | .708 | |
| 10 | .498 | |
| Average | .592 | |

These sugars were, however, quite dry, the average moisture being only 3.58%.

Among a number of commercial samples of sirups bought in the open market there are thirteen sirups giving data for pure products.

*Thirteen commercial sirups, pure:*

| | |
|---|---|
| Average *"lead value"* | .577 |
| Minimum " | .260 |
| Maximum " | 1.100 |

The results from eighteen adulterated sirups are as follows:

*Eighteen adulterated sirups:*

| | |
|---|---|
| Average *"lead value"* | .076 |
| Minimum " | .024 |
| Minimum " | .165 |

While there is considerable variation in the results from pure products, due to method of manufacture, yet there is such a great difference between these and adulterated products that there is no chance for a "doubtful" interpretation.

Experience with this method on several hundred samples has given satisfactory results, in no case "doubtful" and in all cases concordant with the results of a complete analysis. The advantages over other methods now in use seem to be—

(1) The use of neutral lead acetate instead of the subacetate.

(2) A reduction of analytical error to a minimum, the gravimetric result being multiplied by only two instead of by forty, as in the case of another method.

(3) The method is gravimetric instead of volumetric (titration and bulk of ppt.).

(4) Account is taken of solubility of the lead precipitate and the amount of water to be used for diluting and washing is specified.

(5) Error due to products of fermentation in old or spoiled samples is avoided by boiling before precipitation.

(6) With the average water content of 10 to 12 % for sugars and 33 to 35% for sirup, the *"lead values"* are in each case on about the same amount of dry substance, 50 grams of sugar and 50 c.c. of sirup (sp. gr. about 1.33) being taken. It is suggested that for uniform results by different analysts and on different samples, the *"lead value"* be calculated to dry substance.

### VOLUME OF LEAD ACETATE PRECIPITATE.

This cannot be described as an entirely new test but as a modification of the tests in which the volume of precipitate is determined. The object in working out this test was to devise a method which is not subject to the variations of centrifugal methods, a method which would give concordant results on the same sample and by different analysts. This and the two following methods are so simple in execution that they can be used in the kitchen or generally, where no chemical laboratory is available.

The *"volume of lead precipitate"* is reported in cubic centimeters per 5 c.c. and 5 grams of sirup and sugar respectively. The procedure is as follows:

5 c.c. or 5 grams are placed in a glass stoppered 25 c.c. measuring cylinder, 10 c.c. of water and 2 c.c. of 10% lead subacetate (official) solution added; mix thoroughly and allow to settle twenty hours; at the end of this time read the volume of the settled precipitate. For pure maple products this will be over 3 c.c., and is usually over 5 c.c.

Results by this test on forty-two samples give the following results:

| Sample No. | Known to be: | "Vol. Pb. ppt." |
|---|---|---|
| 1—Sugar | Pure | 6.0 c.c. |
| 2—Sugar | Pure | 7.3 |
| 3—Sugar | Pure | 13.6 |
| 4—Sugar | Pure | 4.7 |
| 5—Sugar | Pure | 5.5 |
| 6—Sugar | Pure | 6.2 |
| 7—Sugar | Pure | 7.0 |

| Sample No. | Known to be: | "Vol. Pb. ppt." |
|---|---|---|
| 8—Sugar | Pure | 10.8 |
| 9—Sugar | Pure | 7.6 |
| 10—Sugar | Pure | 10.6 |
| 11—Sirup | Adulterated | 0.8 |
| 12—Sirup | Adulterated | 0.1 |
| 13—Sirup | Adulterated | 0.2 |
| 14—Sirup | Partly maple | 3.7 |
| 15—Sirup | Pure | 7.0 |
| 18—Sirup | Pure | 8.0 |
| 19—Sirup | Adulterated | 0.0 |
| 20—Sirup | Adulterated | 1.5 |
| 21—Sirup | Adulterated | 0.2 |
| 22—Sirup | Pure | 10.7 |
| 23—Sirup | Adulterated | 0.0 |
| 24—Sirup | Pure | 6.7 |
| 25—Sirup | Adulterated | 1.0 |
| 26—Sirup | Pure | 10.3 |
| 27—Sirup | Pure | 10.4 |
| 28—Sirup | Pure | 9.7 |
| 29—Sirup | Adulterated | 0.1 |
| 30—Sirup | Adulterated | 1.0 |
| 31—Sirup | Pure | 7.0 |
| 32—Sirup | Adulterated | 1.5 |
| 33—Sirup | Pure | 10.0 |
| 34—Sirup | Adulterated | 1.6 |
| 35—Sirup | Adulterated | 2.7 |
| 36—Sirup | Pure | 7.8 |
| 37—Sirup | Adulterated | 1.3 |
| 38—Sirup | Adulterated | 2.0 |
| 39—Sirup | Pure | 7.9 |
| 40—Sirup | Pure | 7.8 |
| 41—Sirup | Adulterated | 1.7 |
| 42—Sirup | Adulterated | 0.0 |
| 44—Sirup | Partly maple | 5.0 |
| 49—Sirup | Pure | 7.7 |

For the pure products in the above, the results are as follows:

| | Sirups. | Sugars. |
|---|---|---|
| Average | 8.5 | 7.9 |
| Minimum | 6.7 | 4.7 |
| Maximum | 10.7 | 13.6 |

The results on the adulterated samples are in all cases much lower than those of pure products and results on samples obtained so far have always corresponded with the complete analysis.

TWO NEW PRELIMINARY TESTS.

*The Color Test.*—The color of maple products was discussed under the subject "Color," and as may be readily understood, the color in pure products is due to other substances besides caramel. Since amyl alcohol does not dissolve caramel, and preliminary experiments showed that it extracted no color from adulterated or imitation products, further experiments were made on a larger number of samples. It was found that a product containing no maple never gave any color to the amyl alcohol; all pure products gave a very dicided color, most of them a dark brown; some of the light colored products gave only a pale brown color.

The test is made as follows: Put 15 c.c. of sirup, or 15 grams of sugar and water to make 15 c.c., in a test tube or glass-stoppered cylinder; add 3 c.c. of pure amyl alcohol and 1 c.c. of a 20% solution of phosphoric acid and mix the whole thoroughly by shaking; let settle and note the color of the amyl alcohol layer.

A number of preliminary tests showed that amyl alcohol alone does not in all cases dissolve enough coloring matter to give a good indication; some of the coloring matter is soluble in water and remains so unless phosphoric acid is added, which causes most of the coloring matter to go into solution in the amyl alcohol. The test gave the following results:

| Sample No. | Known to be: | Color by Amyl alcohol test: |
|---|---|---|
| 1—Sugar | Pure | Good. |
| 3—Sugar (very dark) | Pure | Very dark. |
| 4—Sugar | Pure | Good. |
| 5—Sugar (light) | Pure | Fair. |
| 6—Sugar | Pure | Good. |
| 7—Sugar | Pure | Good. |
| 8—Sugar (light) | Pure | Fair. |
| 9—Sugar | Pure | Good. |
| 10—Sugar | Pure | Good. |
| 18—Sirup | Pure | Good. |
| 43—Sirup | Cane and maple | Fair. |
| 45—Sirup | Cane and maple | Trace. |
| 46—Sirup | Pure | Good. |
| 48—Sirup | Mostly cane | None. |
| 51—Sirup | 50% maple | Fair. |
| 52—Sirup | Pure | Good. |
| 53—Sirup | Cane and maple | Little color. |
| 54—Sirup | Cane and maple | Trace. |
| 55—Sirup | 20% maple | Trace. |

| | | |
|---|---|---|
| 56—Sirup | Pure | Fair. |
| 57—Sirup | Cane and maple | Trace. |
| 58—Sirup | "Maple flavor" | None. |
| Sirup | Cane + caramel | None. |

## THE FOAM TEST.

This test was the result of the observation that sirups or sugars which are mostly made of cane do not give any trouble and produce hardly any foam when ignited for ash; pure maple products, on the other hand, often produce considerable foam on ignition. Preliminary experiments showed that a pure maple sirup diluted with water and shaken will produce a persistent foam, while adulterated products produce very little, and this little disappears quite rapidly. The test as now made is as follows: Place 5 c.c. of sirup into a narrow tube or cylinder graduated in tenths of a c.c.; add 10 c.c. of water and shake vigorously for half a minute; let stand ten minutes and read volume of foam.

This test gave the following results on sirups:

| Sample No. | Sample known to be: | c.c. foam. |
|---|---|---|
| 11 | Partly maple | 1.5 |
| 12 | Partly maple | 2.0 |
| 13 | Adulterated | 0.0 |
| 14 | Partly maple | 2.5 |
| 15 | Pure maple | 5.0 |
| 18 | Pure maple | 3.5 |
| 19 | Adulterated | 1.0 |
| 20 | Adulterated | 0.5 |
| 21 | Adulterated | 1.5 |
| 22 | Pure maple | 4.0 |
| 23 | Adulterated | 1.0 |
| 24 | Pure maple | 3.5 |
| 25 | Adulterated | 1.0 |
| 26 | Pure | 0.1 |
| 27 | Pure | 1.0 |
| 28 | Pure maple | 3.0 |
| 29 | Adulterated | 0.1 |
| 30 | Partly maple | 1.5 |
| 31 | Pure maple | 6.0 |
| 32 | Adulterated | 1.5 |
| 33 | Pure maple | 4.0 |
| 34 | Adulterated | 1.0 |
| 35 | Adulterated | 1.5 |
| 36 | Pure maple | 3.5 |

| | | |
|---|---|---|
| 37 | Adulterated | 0.1 |
| 38 | Adulterated | 0.5 |
| 39 | Pure maple | 3.5 |
| 40 | Pure maple | 5.0 |
| 41 | Adulterated | 1.5 |
| 49 | Pure maple | 4.0 |
| 59 | Adulterated | 1.0 |

Samples 26 and 27, on complete analysis gave results of pure maple products; they had, however, a most disagreeable odor and flavor, reminding one of decomposing or putrifying nitrogenous organic matter, especially like putrifying egg albumen; these two samples were therefore not normal and but little foam was produced by each. In this list the eleven pure sirups gave an average of 4.1 c.c. foam, minimum 3.0 c.c., maximum 6.0 c.c.; the adulterated or mixed products all gave less than 3.0 c.c.

## ADULTERATION.

The writer's original intention was to collect data from reported analyses to show percentage of adulteration for different years and for different localities. Such percentage figures, however, would not represent actual conditions, since in collecting samples for the analyst, the inspectors select those that are suspicious or give some indication of adulteration. In a general way it may be said that on account of the various pure food laws and pure food agitation, but few samples of fraudulent maple products are on the market; there are of course a great many, in fact the majority of maple products are mixed with cane sugar, but these cannot be classed as fraudulent if properly labeled. In some cases considerable ingenuity is displayed by the "mixers" in making a label for mixtures of maple and cane products.

Ten or fifteen years ago, the chief adulterant for maple products was glucose; some cane sugar was also used. The reasons why glucose was used were its cheapness and the fact that it prevents crystallization of sucrose. The "mixers" soon found that analysts had no difficulty in detecting glucose, and as the laws with reference to adulteration became more stringent, glucose disappeared as an adulterant, until to-day it is very rare to find a maple product with glucose. The "mixers" were not long in discovering the fact that the sugar in maple sap is identical with that found in the sugar cane, namely sucrose, and cane sugar became and still is

to-day the chief adulterant for maple products. For a number of years chemists were unable to detect the addition of cane sugar to maple products; even now there are to be found analysts who will not undertake to determine the presence of cane sugar, or the addition of an adulterant; and indeed, it is not a simple matter, and may well be left for the analyst experienced in maple products. Since no indication of adulteration can be gained by a study of the sugars, analysts have turned their attention to research on the other constituents. Some of the earliest work in this direction was done at the University of Buffalo, in the laboratory of Prof. H. M. Hill. The results of his investigations and analyses were never published, and several years before the work of other investigators was published, Prof. Hill was the only analyst in this part of the country who would undertake to analyze and detect adulteration of maple products.

As commonly used and understood, adulteration means the addition of any foreign substances; legally, and according to pure food laws, this may or may not be adulteration; a maple product is adulterated when it contains any foreign substances and is labeled or sold as pure maple; a sirup or sugar cannot be regarded as adulterated when its label tells the contents. With reference to labeling mixtures of cane and maple sirups, Food Inspection Decision 75, U. S. Department of Agriculture, says: When both maple and cane sugars are used in the production of sirup the label should be varied according to the relative proportion of the ingredients. The name of the sugar present in excess of 50% of the total sugar content should be given the greater prominence on the label; that is, should be given first. For example, a sirup the sugars of which consist of 51% cane and 49% maple should be properly branded as "Sirup made from cane and maple sugar," or as "Cane and maple sirup." The terms "maple sirup" and "maple sugar" may only be used on the label as part of the name when these substances are present in substantial quantities as ingredients. They should not appear on the label as part of the name when only a small quantity of these substances is used to give a maple flavor to the product. A cane sirup containing only enough maple to give a maple flavor is properly labeled as "Cane sirup, maple flavor," or "Cane sirup flavored with maple." The presence of cane sugar (sucrose) should be declared as *cane sugar*, and not as *white sugar*.

LEGAL STANDARDS.

A marked improvement in food legislation and pure food laws is the addition of standards for food products. In nearly all States where maple products are mentioned in the laws there is also a standard given. The standards adopted by the U. S. Department of Agriculture are given in Circular 19, and are as follows.

"*Maple sirup* is sirup made by the evaporation of maple sap or by the solution of maple concrete, and contains not more than 32% of water and not less than 0.45% of maple sirup ash."

"*Maple sugar* is the solid product resulting from the evaporation of maple sap, and contains, in the water-free substance, not less than 0.65% of maple sugar ash."

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The writer is indebted to the many friends who have helped to make this article possible. I am under obligations to a number of western New York farmers for extending to me the privilege of visiting their maple groves and camps for several seasons. I am especially indebted to the following: Prof. C. H. Jones, chemist, Vermont Experiment Station; Prof. Cowell, Supt. South Park Botanical Gardens, Buffalo; Dr. Hill, Professor of Chemistry, University of Buffalo, and Mr. Frank Severance, Secretary Buffalo Historical Society.

University of Buffalo,
Buffalo, N. Y.

## Erratum.

Vol. CLXVI, No. 5, November, 1908, pp. 390 and 392.

Page 390, last three lines read:

"At Queen Lane, the system will have each of the five features mentioned above, the water flowing, by gravity, from the sedimentation reservoir (the south basin of the"

Page 392, Queen Lane filter plant, omit "Low lift pumps over N. basin."

## MINERAL PRODUCTION OF THE UNITED STATES IN 1906.

The United States Geological Survey's annual report on the mineral resources of the United States for 1906 is now ready for distribution. The separate chapters of this volume have been published from time to time as the statistics for the various minerals became available, and these assembled chapters form a book of 1300 pages, provided with a table of contents, an introduction and an index. The volume comprises 47 separate reports, prepared by 27 authors, covering entirely the mineral production of the country, with descriptions and discussions of the deposits from which the minerals are obtained, reports of imports and exports and many comparisons of home and foreign production, statements of prices and prospects, and notes on the technology of many of the products.

In its general features this volume is similar in form and scope to the preceding reports on mineral resources published by the Geological Survey, the series covering altogether a period of twenty-seven years. For twenty-five years of this period the work of gathering these statistics has been in charge of Dr. David T. Day, but the present volume has been prepared in part under the supervision of Mr. Edward W. Parker, who has been for many years Dr. Day's assistant and collaborator. Hereafter Dr. Day will give his attention chiefly to the compilation of reports on petroleum and natural gas, substances concerning which accurate information has been difficult to obtain, and Mr. Parker will have administrative charge of the work of collecting and compiling the various reports and statistics that are published in this annual volume.

Since the Survey began its work on the mineral statistics of the country the value of the mineral production has increased more than five fold. From $364,928,298 in 1880 it has risen gradually, with some fluctuations, to $1,902,517,565 in 1906, a sum representing the value of the mineral products in their first marketable condition. The larger producing States contributed to this total in 1906 in the following order and approximate proportions: Pennsylvania, 30 per cent.; Ohio, 11 per cent.; Illinois, 6 per cent.; New York and West Virginia, 4 per cent. each; Montana, Colorado, and Michigan, 3.5 per cent. each; Arizona and Missouri, 3 per cent. each; Alabama and California, 2.5 per cent. each. The value of the mineral output of each of these twelve States was more than $50,000,000, and their combined value amounted to more than $1,488,000,000.

The value of the metallic products of the country increased from $702,453,101 in 1905 to $886,110,856 in 1906; that of the non-metallic products from $921,075,619 to $1,016,194,350. As heretofore, coal and iron are our most important mineral products, the value of the coal in 1906 having been $513,079,809, and that of the iron $505,700,000. Copper is third in value, with $177,595,888; clay products are fourth, with $161,032,722; gold is fifth, with $94,373,800, and petroleum is sixth in value, with $92,444,735. It is noteworthy that the value of the silver output, $38,256,400, was exceeded by that of lead, which amounted to $39,917,442.

The greatest increase during the year is shown in the production of coal, copper, and cement.

The task of gathering the growing mass of statistics of the country's mineral production is made more exacting from year to year by the urgent demand for increased accuracy. There is no law requiring the producers to submit statistics of their production to the National Survey, and their voluntary cöoperation in this work is one of its most noteable features.

# THE FRANLLIN INSTITUTE.

## Ballentine's Process of Testing the Hardness and Density of Metals.

[*The Report of the Franklin Institute, through its Committee on Science and the Arts, on the Process of Testing the Hardness and Density of Metals and other Materials, devised by William I. Ballentine, of Chicago, Ill. Sub-Committee: G. H. Clamer, Chairman; A. E. Outerbridge, Jr., A. W. Allen.*]

[No. 2417.]

Before discussing this process for testing the hardness and density of metals, and other materials, it would perhaps be well to understand exactly what is meant by "Hardness." "Hardness" is that property of material which resists a change in the relative position of the molecules of the material without separating them from each other. "Hardness" may therefore be tested and recorded as "the resistance to indentation."

Quite a number of methods of testing hardness have been proposed, some of which are at present in use, the following being those which are most prominent:

1st.—Prof. Turner's method, which depends upon the weight in grams required to cause a diamond to scratch a polished surface.

2d.—The Drill test, proposed by Chas. A. Bauer, the principle involved being that with a drill running at a constant speed with a constant load, the hardness is proportionate to the number of revolutions made by the drill, and the depth of the penetration.

3rd.—The method proposed by Mr. Keep. Mr. Keep devised a machine on the same principle as that involved in the Bauer test,

but the machine has the additional device which records any variation in hardness for the full depth of the test.

4th.—This is known as the Brinell Ball Test. This method, devised by Brinell, is the one at present most extensively used. This test depends on the principle that hardness is proportionate to the indentation made by a hardened steel ball into the test sample under a constant load. Brinell has devised a machine which operates on this principle, and by measuring the diameter of the impression made, ascertaining the area of the impression in square millimeters, and then dividing this into the amount of pressure used in kilograms, the resultant figure is a numeric expression of the hardness of the material tested. This figure is called a "Hardness numeral." It is therefore possible to compare the hardness of any particular sample tested with others by simply comparing these numerals.

The above processes, it will be seen, all depend on some method of recording the resistance to indentation. In getting back to our definition of "Hardness," they record the resistance of material to a change in the relative position of the molecules of the material, without separating them from each other.

The process which has been invented by Mr. Ballentine, and which is covered by patent granted June 4th, 1907, Patent No. 855,923, presents an ingenious method and device for recording resistance to indentation. The process depends on the following fact:

> "That a known and constant weight which is allowed to fall through a known and constant distance, will exert a known and constant force upon an anvil, and if the force is transmitted to a pin which is capable of indenting the material tested, the relative hardness of the materials can be determined by the depth of indentation."

It would be an exceedingly difficult task, however, to measure this indentation accurately, and Mr. Ballentine has therefore inserted a recording disc, which is made of a softer metal than the metal being tested, and therefore receives an indentation proportionate to the resistance offered by the material tested to the indentation of the test pin.

The apparatus used consists of merely a guiding tube, a plunger, which is held at the top of the guiding tube by a trigger, and at the bottom of the tube an anvil and test pin. There is also

attached to the guide tube a spirit level, to see that the tube is held exactly in a vertical position. At the bottom of the tube there are a number of holes to allow for the escape of the air, forced out by the dropping of the plunger. The recording disc is attached to the bottom of the plunger.

The method of operating the apparatus in making a hardness test is as follows.

First:—The thickness of the recording disc is determined by a micrometer; the same is then attached to the plunger. The plunger is now held at the top of the guiding tube by the trigger, and after seeing that the guiding tube is in an exactly vertical position, as shown by the spirit level, the trigger is released. The plunger, together with the guiding disc attached to the bottom of it, descends and strikes the anvil, which is directly connected to the test pin. The result is that the test piece is indented and the recording disc is also indented or compressed. The reduced thickness of the recording disc is now measured by the micrometer, and the difference between this thickness and the original thicknes represents a numeral, which can be taken as a relative number of hardness number of the material tested. Thus, for instance, if the original thickness of the recording disc is .300 and after compression it is .200, the hardness numeral would be .100.

The principal advantage possessed by this method of testing over others which have heretofore been proposed is the fact that the apparatus is entirely portable, and can be carried to the test piece. In other forms of apparatus it is necessary to carry the test piece to the apparatus and to prepare these pieces for the purpose of testing. The Ballentine apparatus can be taken to any casting or piece of metal in the shop or foundry, and by simply flattening a very small area, a test can be made right then and there, without defacing the casting, or going to the inconvenience of cutting off a test piece and taking it to the laboratory, all of which occasions more or less inconvenience. It is by reason of the portability of the apparatus that it is particularly useful in machine shop service, it being possible to determine beforehand the hardness of a piece to be machined, thereby guaging to a certain extent the proper speed and cut which should be taken in machining.

The following is a list of the tests which were made by this method, which show that the results were quite concordant:

HARDNESS OF BABBITT METAL.

Link-Belt Company,
Chicago, April 23d, 1907.

| Recording Disc No. | Thickness before test | Thickness after test | Penetration, or record of hardness | Test piece mark | Kind of metal |
|---|---|---|---|---|---|
| 1. | .29680 | .22555 | .07125 | A | From the Hoyt |
| 2. | .29785 | .22800 | .06985 | A | Metal Co., St. |
| 3. | .29725 | .23230 | .06495 | B | Louis |
| 4. | .29760 | .23555 | .06205 | B | |
| 5. | .29692 | .24130 | .05562 | C | |
| 6. | .29738 | .24155 | .05583 | C | |
| 7. | .29923 | .22730 | .07193 | I | Copper Hard |
| 8. | .28697 | .22840 | .06857 | I | " " Babb |
| 9. | .29692 | .24975 | .04617 | II | Common Babb't |
| 10. | .29745 | .25435 | .04310 | II | " " |
| 11. | .29788 | .28975 | .00813 | III | Lead |
| 12. | .29680 | .28922 | .00758 | III | " |
| 13. | .29793 | .22145 | .07648 | IIII | Bearing Metal |
| 14. | .29725 | .21890 | .07835 | IIII | |

The Chairman of the Committee has also made a number of tests to determine the accuracy of the device, with the following results:

*First—Special Babbitt.*

1st Test..... .1005
2d " ..... .1010
3d " ..... .1022

*Second—Plastic Bronze.*

1st Test..... .1245
2d " ..... .1244
3d " ..... .1242

*Third—Genuine Babbitt.*

1st Test..... .1155
2d " ..... .1147
3d " ..... .1165

*Fourth—Phosphor Bronze.*

1st Test..... .1310
2d " ..... .130
3d " ..... .1282

*Fifth—Plumbic Bronze.*

1st Test..... .0996
2d " ..... .0945
3d " ..... .090

*Sixth—Copper, cut from ingot.*

1st Test..... .130
2d " ..... .131

Attention is called to the fact that although the title of Mr. Ballentine's patent is "A Process of Testing the Hardness and Density of Metals and other Materials," the process, as a matter of fact, is a process of testing Hardness only, which properly is entirely distinct from what is technically known as "Density." Tests for hardness as made do not record the density.

The following tests, which were made of a cast-iron wedge, test No. 1 being in the thickest part of the wedge, test being made at uniform distance between tests No. 1 and No. 14, along a central line drawn on the face of the wedge. Tests No. 15 and No. 16 were made nearer the bottom of the wedge, and intermediate between the central line and the edge. Tests are as follows:

| Test No. | Thickness of Disc before test INCH | Thickness of Disc after test INCH | Penetration INCH |
|---|---|---|---|
| 1. | 0.28890 | 0.15665 | 0.13225 |
| 2. | 0.28870 | 0.15585 | 0.13285 |
| 3. | 0.28880 | 0.15430 | 0.13450 |
| 4. | 0.28895 | 0.15360 | 0.13535 |
| 5. | 0.28915 | 0.15325 | 0.13590 |
| 6. | 0.28875 | 0.15375 | 0.13500 |
| 7. | 0.28910 | 0.15400 | 0.13510 |
| 8. | 0.28865 | 0.15355 | 0.13510 |
| 9. | 0.28895 | 0.15352 | 0.13543 |
| 10. | 0.28915 | 0.15377 | 0.13538 |
| 11. | 0.28900 | 0.15312 | 0.13688 |
| 12. | 0.28900 | 0.15295 | 0.13605 |
| 13. | 0.28950 | 0.15267 | 0.13683 |
| 14. | 0.28860 | 0.15210 | 0.13650 |
| 15. | 0.28900 | 0.15280 | 0.13620 |
| 16. | 0.28920 | 0.15153 | 0.13767 |

In consideration of the ingenuity and novelty of the process as above described, and the value of a simple and convenient method and apparatus for testing the Hardness and Density of metals, in both practical and scientific application, as has been invented by Mr. Wm. I. Ballentine, the Institute recommends the award of the John Scott Legacy Medal and Premium.

Attest: WM. H. WAHL, *Secretary.*

Philadelphia, April 1, 1908.

## REPORT OF LUMBER PRODUCTION OF THE LAKE STATES.

The Lake States, one of the greatest forest regions that ever contributed to the lumbering activities of any country, are rapidly falling behind in timber production, according to a preliminary statement just issued by the Bureau of Census.

Statistics concerning the annual output of forest products, collected by the Bureau of the Census in cooperation with the United States Forest Service, from more than 2,100 saw-mill operators in Michigan, Wisconsin and Minnesota—the big three—have shown that the cut last year was only five and a-half billion feet of lumber, a big pile, yet 12 per cent. less than the cut of the preceding year.

The heavy inroads made in the exploitation of the timber resources of the large lumber States on the Great Lakes have been too much for the great forests, and the amount available for cutting is getting lower each year. The decadence of the lumbering industry in this region is forcefully illustrated in the drop in the white pine cut during the past ten years. Michigan's forests of this valuable tree were the richest in the wo ld and were often said to be inexhaustible. The folly of such a statement is shown by the report that the cut of white pine in Michigan last year was only one-fourth of what is was in 1899, only eight years before.

In lumbering the forests no thought was given to anything but immediate money returns, and consequently the countless fires running over the land, after the timber was stripped, have killed young growth over wide areas and greatly impoverished the soil. Now 6,000,000 acres, or nearly one-sixth of the State of Michigan, known as the "pine barrens," have been thrown on the delinquent tax list and are a burden to the people. Under proper forest management this land would have been producing timber to-day. Between 1899 and last year the white pine production fell off nearly as much in Wisconsin as in Michigan. In Minnesota, the State which now contains the largest amount of virgin white pine, the decrease in the same period was nearly one-third.

Taking the three States together, pine constituted nearly forty-six per cent. of the total lumber production in 1907, hemlock a little more than twenty-seven per cent. and maple ten per cent., the balance being made up mostly of basswood, birch, tamarack, elm, beech, oak, spruce, ash, and cedar, in the order given. The pine is mostly white and Norway, which are grouped together under the general trade term of "northern pine." Pine made up over nine-tenths of the lumber produced in Minnesota, one-third of that produced in Wisconsin, and less than two-fifths of the total cut of Michigan.

Along with this great decrease in pine, there have been relatively as heavy decreases in the most valuable of the hardwoods, oak, elm, and ash. Little more than one-fifth as much oak was cut in the Lake States last year, for instance, as in 1899, while the cut of elm and ash was but half of that of eight years earlier. As is always the case, the decreasing supplies of the more valuable woods have caused those once considered of little or no value to be drawn upon heavily. This has been particularly true with hemlock, so that now more hemlock than pine lumber is manufactured in Wisconsin, and twice as much hemlock as pine cut in Michigan. There have been heavy increases in the use of maple, birch, and beech within the past few years, but the maximum cut of these species is probably near at hand; and taking all of the hardwoods together, there has been a slight falling off since 1899.

# ELECTRICAL SECTION.

*(Stated meeting held Thursday, November 5, 1908.)*

## Electricity in Refrigeration.

By R. Louis Lloyd.

It is probably not necessary for me to discourse here on the reasons why ice, or its counterpart, artificial cold, are of such importance in the commercial world to-day: how by segregation and civilization mankind has desires and necessities which rise above the immediate provisions of nature, desires which can be satisfied only by the supply of articles inherently poorly adapted existence if natural conditions only prevail.

Artificial warmth, artificial light, artificial power, artificial cold are necessities of civilization. And as necessity is the mother of invention, our engineers have supplied the refrigerating machine. The constantly increasing contamination of our water courses and other bodies of water where ice was harvested, has been a potent factor toward the rapid introduction of machines for ice making. Latter-year improvements have so enhanced the efficiency of the small sizes that the demand has been continually augmented, with the natural result of turning to the electric motor as the most convenient, simple and economical driving power.

The management of our local public electric service company early recognized the enormous possibilities of electric refrigeration and have done much toward popularizing and pushing its use. The results have been very gratifying, and Philadelphia can probably show to-day a larger number of small sizes of refrigerating machines than any city similarly situated. They enter into almost every line of business handling perishable goods, not even omitting the undertaker and the morgue.

I can probably not do better than give you a description of a few of the equipments now in operation in the several lines. We will

consider first the outfit of a retail meat shop in the upper part of the city where a "baby" Larsen-Baker compressor is operated by a three H.P. motor. The machine is set up in the basement under the meat box, which is on the floor above. This box is 9′ x 6′ x 11′ high, and holds at times as much as six sides of beef, four or five calves and a dozen lambs, a total of a ton and a half of meat. This is a direct expansion system with a brine tank auxiliary for storage. This tank takes the place of the ice bunker in an ordinary meat box and will hold the temperature down low during the non-operative hours of the machine. With a temperature of 34 degrees when shutting off at night, a rise of only four degrees will be experienced by morning.

In addition to the main box, the counter cases in the store and a corn-beef tank are also refrigerated.

At this time of the year, four hours operation per day is sufficient. In summer about nine hours are necessary, while during January and February the machine is not used at all, unless an unusually hot spell visits us. When ice was used, the yearly bill was $425. The power bill for the first year was $250 and for the second $207. This installation cost less than $1000. Adding interest and depreciation charges at 15% to the power bill makes the total operating cost $360 per year, a saving of 14%. To say nothing of the added advantages of lower temperature, more constantly supplied, dry cold and an improved display counter which increases trade.

In contrast let us turn to a large installation for a combined wholesale and retail meat business. It consists of two 25-ton Vilter refrigerating machines, each driven by a fifty H.P. Northern motor, chain geared; one Triplex plunger brine pump, driven by a 5 H.P. motor; one deep-well pump, driven by a 3¾ H.P. motor; one large refrigerator box or cooler 60′ x 17′; three small refrigerator boxes or freezers 20′ x 17′; one pickling room 37′ x 19′ x 11′ high; one brine tank 19′ x 5′ x 8′ deep, situated in the latter room. About 5000 gallons of brine.

The system is brine circulation exclusively, all of the expansion coils being located in the brine tank. Three or four hours' operation of the machine is usually sufficient to reduce the temperature of the brine to five or eight degrees above zero. It is then pumped through pipes in the freezers and the bunker of the cooler during six hours, which keeps these rooms at the proper

temperature. After a shut-down of about fifteen or twenty hours this brine has risen to about fifteen degrees.

The object of putting in two refrigerating machines was to permit one machine to rest during the heavy duty in summer and also to allow for growth of the business. The two have never yet been needed both working at the same time. In fact, six hours' work in twenty-four for one machine in the hottest summer weather so far encountered has been found ample. In winter weather one hour's work for the machine and about one and one-half hours' operation for the brine pump is all that is required to produce the desired temperature.

The cooler usually holds about 20,000 pounds of meat, and is maintained at thirty-five degrees. This box is well insulated with layers of cork laid in asphalt pitch. There are three doorways in this box and it is well lighted by incandescent globes.

The wall and counter cases in the store are also cooled by brine pipes located above in the former, and at the bottom of the latter. This permits of the display of choice cuts of meat without fear of deterioration.

The freezer was divided into three rooms in order to accomplish better results and allow considerable elasticity in the accommodations. In certain seasons of the year it is necessary to take care of more of those delicacies which require the very low temperature; and as arranged one, two or three sections can be utilized independently. The temperature can be brought as low as zero in any of these rooms if necessary. Fifteen degrees, however, is found to be ordinarily sufficient.

The pickling room is cold enough at thirty-five degrees, but on account of the presence of the brine tank, the temperature is usually down to thirty degrees without circulation in the coils of this room.

Since the plant was put into operation, in the early spring of 1907, there has not been the slightest delay or trouble from the equipment. It has operated on a 20% load factor and the results have been entirely satisfactory.

The condensing water is obtained from an artesian well, the water being pumped from a sixty-foot depth by a $3\frac{3}{4}$ H.P. motor, above mentioned.

It is rather difficult to make any comparisan between the cost of operation of this equipment and the cost of ice. Of course

the freezers could not have been used and the low temperatures of the other boxes could not have been maintained. Outside storage charges would have been incurred. The heaviest consumption was 4017 K.W. hours for the month of July, and he lightest 1420 K.W. hours in January. The owner of this plant is highly gratified with its operation.

Early in 1907 the Leo. Niessen Co. installed a six-ton machine

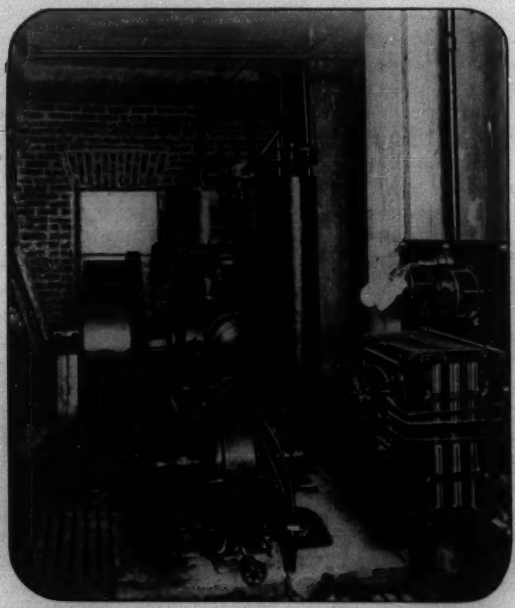

Fig. 1. Six ton refrigeration machine and motor. Silent chain drive.

to take care of their immense stock of flowers in two refrigerators of their new store. See Fig. 1. One box is in the basement and is used for smilax and green stuff. This is 8′x20′ internal dimensions and 8′ high. The desired temperature is thirty-two degrees. The system used is direct expansion with brine tank auxiliary. After fresh crates and boxes have been put away and the temperature has risen ten or fifteen degrees, one hour's operation of the ma-

chine will bring the temperature down to thirty-two degrees. The valves feeding this box are then closed, and the work of the machine is all done in the main box in the store. This one is 40′ x 10′ x 12′ high, has two doors and two electric lights. They are burning almost constantly and the doors are open every few minutes throughout the day, which lasts from 7 A.M. to 9 P.M. This box has two brine tanks the length of the box, 3′ deep x 15″ wide. They each contain 300 gallons of brine. All the cooling tubes are in and around these tanks. For the better circulation of the air and to obtain a more uniform temperature, air flues are built on both sides extending to within two feet of the floor. The refrigeration is produced in a sort of a trough which prevents the cold air falling immediately against the flowers on the upper racks. The flues carry it down the sides to be distributed below.

Three to five hours per day the year through is all that this machine is required to operate. It is giving highly satisfactory service and has needed no repairs to date—nearly two years. The bills for power have varied from $43 to $63 per month. This would buy less than half a ton of ice per day. Three times this much ice would not give them equivalent results of cooling. The load factor of the motor for the year is about 40%.

Early last year the proprietors of one of our most prominent retail florist shops decided to adopt mechanical refrigeration.

They had a very handsome display case along the east wall of their establishment, 16½′ long and 9′ high and 42″ wide, embracing about 500 cubic feet. It consisted of a show case with three shelves, drawers below, and an ice bunker above.

These shelves hold jars and vases of cut flowers in water, and they were usually kept full at all times, forty jars holding probably 200 or 300 pounds of water, being the average quantity, and this was renewed daily.

The drawers below contained the smilax and green stuff and were well filled. Openings in the floor and the main case permitted the coldest air to circulate down to and around these goods. Both doors and drawers were opened frequently. There were four of each and the openings would average probably four times per hour each.

Under these conditions it was found necessary to use 500 to 700 pounds of ice each day to maintain a temperature of 54 to 55 degrees.

The annoyance and inconvenience of handling were great. The ice bill for one year was $501. We contended that the cost of power to operate a refrigerating machine to produce equal results would not be over half this amount. A contract was made for a Brunswick refrigerating machine of one ton capacity, which was guaranteed to produce the desired results. The cost of the complete installation in operating condition was a little over $1000. The installation was completed and the machine operating the last week in May, 1907.

In the ice bunker above the case four narrow brine tanks 14′ 9″ long 18″ high and 4″ wide were placed, and the ammonia expansion pipes led into them. Each tank was cooled by 100 feet of one-inch pipe, bent zig-zag and arranged in seven rows each 14′ long. One barrel, or 350 pounds of calcium chloride salt was dissolved in enough water to fill these four tanks, making a weak solution, Sp. Gr. 1.05, with a freezing point just below 26 degrees F. The idea was to freeze this solid and have a result similar to that obtained from ice.

It worked out admirably in practice. At eight in the morning, when the store is opened, the machine is started in operation. The temperature in the cases at this time is found to be just about as it was left the night before, about 45 degrees. They now renew the vases and jars and put in fresh flowers from the hot house. The doors are opened constantly for quite a while, and the temperature rises in the cases sometimes as high as 60 degrees. This will naturally vary at the different seasons of the year, depending upon the temperature of the room, and the water supply. The cases are soon brought down to the desired temperature, and toward evening the tanks will have frozen solid again. The machine is then stopped and remains so over night.

The results have been very satisfactory, and the avoidance of the bother and trouble of handling ice is in itself justification for making the change.

The proprietors have ordered that the machine be overhauled every year, a preventative measure.

This is the way the account stands for the first year:

| | |
|---|---|
| Cost of electric power | $301.07 |
| Interest, depreciation and repairs | 157.00 |
| | $458.07 |
| As compared to ice | 501.00 |
| Saving | $43.00 |

This is numerically not very large, but we must also consider the absence of labor and abuse of this fine case incident to the continual filling of the ice chamber when ice was used. These costs actually existed though not readily shown.

The motor used is a three H.P. Peerless. A test shows it to be taking almost two K.W. as a steady input. It is belted direct to the driving pulley of the machine, which runs at 280 revolutions per minute.

Next is a dairy which handles 4000 quarts of milk per day and requires nine wagons for delivery purposes. The refrigerating machine used is an eight-ton Buffalo plant, driven by a fifteen H.P. motor. The expansion coils are all submerged in a large brine tank situated above the refrigerator box, containing 2000 gallons of calcium chloride brine. Eight or ten hours operation cools this mass to 10 deg. or 20 deg. F. above zero. It is kept in motion by a small pump operating twelve or fifteen hours out of twenty-four, which also circulates it through the cooling coils of the pasteurizer. Two hours are required to pasteurize the 100 cans of milk. This is a continuous process with the improved apparatus and after heating it is rapidly cooled to 40 deg., bottled and set in the refrigerator. This latter is a well insulated room, 26′ x 14′ with 10″ walls. About six feet of the rear end is partitioned off for a sort of a freezer for the better keeping of the cream. This part is cooled as low as 28 deg. The main room ranges from 32 deg. to 40 deg.

The electric power for an entire twelve months for this refrigerating machine was $786, with a K.W. hour consumption of 17403. We notice, however, that the individual months varied greatly, ranging from 2832 in July to none at all in February. The load factor for the year was 50.7%. This is somewhat lower than the average load factor for dairies.

We will now turn our attention to a soda fountain. This, with its counterpart, the saloon installation, is the most difficult yet encountered to properly care for. The requirement of having the beverage served at nearly a freezing temperature and at the same time to constantly avoid its freezing up in the pipes, makes the problem. It is overcome by what is called sweet water circulation. The freezing coils are submerged in a tank of ordinary water of considerable volume. Some ice is allowed to form in this tank, but inasmuch as ice is a non-conductor it acts some-

what as a barrier to further formation after the first coating of a half inch or so. In addition the water is kept in constant circulation during the cooling process. (See Fig. 2.)

The plant in question consists of a three-ton Brunswick refrigerating machine, driven by a 7½ H.P. motor. The water tank is probably 15′ x 4′ x 3′ deep and contains all the expansion coils. A small rotary pump, requiring ¼ H.P., direct connected to a motor, keeps the water in almost constant circulation from the

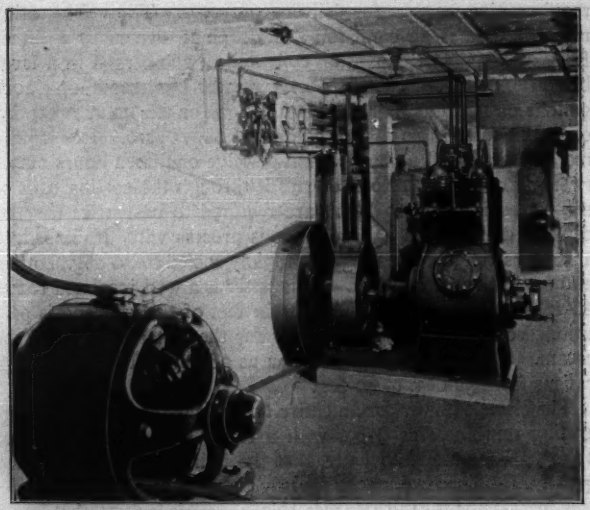

Fig. 2. Three ton refrigerating machine and motor. Belt drive.

tank through three soda fountains and return. The pipe leading from the tank through the pump carries the water at nearly 32 deg. temperature up into the lower compartments of the three fountains in sequence, then up into the coil chamber where it discharges over the soda water pipes, overflowing to the next fountain, and to the last in turn, from which it is returned to the cooling tank.

The operation is found very satisfactory, giving considerably lower temperature to the beverages than was obtained from ice.

The power bill is about one-half the former ice bill, and the confusion, delay and slop of ice deliveries avoided. Total K.W. hours for one year 11428, which is a load factor of 61%. The power used in the hottest month, August, was nearly double that of the cold month, January. The average running time of the compressor was about five hours, while the pump has of late been running continually. It was found that the soda water coils were too long getting chilled in the morning after an all-night rest in the hot store. This loss could no doubt be avoided if a little more attention were given to insulation of soda fountains.

I quote from an article in September, "Ice and Refrigeration," describing a modern bakery at Columbus, Ohio. "At first thought it may seem that refrigeration could have little to do with baking bread, but as a matter of fact it is the refrigerating machine that gives the baker the control over the processes of bread making requisite to the ensuring of the all-important uniformity in product now demanded by the customer."

All the new bakeries use refrigerating machines. Not only the bread bakers, but pie bakers as well. One of the most, if not the most modern and up-to-date establishment of its kind in the world is just about completed and beginning to do business on Tenth Street below Walnut. The Horn & Hardart Baking Company have spent $275,000 in building and equipping this new food-factory to supply the needs of its numerous "Automats" and restaurants, doing strictly a light lunch business. The refrigerating feature is worthy of our attention. (See Fig. 3.) It consists of two eight-ton units, belt-driven from a main shaft so arranged with clutch pulleys that one, or both, or neither can be operated at will. A 40 H.P. motor turns the shaft. The artesian well pump is also connected to the same and operates continuously with either refrigerating machine. Direct expansion, with still brine storage, is used in each of the six refrigerator boxes, the largest of which is the pastry box in the bakery proper. This is 50′ x 10′ x 8′ high, and will hold more pies and things than are consumed by a regiment. The fruit box is just half this size. The meat box is 20′ x 10′. Two small boxes take care of the butter and the immediate supplies for the lunch counters in the building. There are in addition an eight-can ice cream cabinet, an ice storage room and two Tyson Ice-Cream machines. The ice storage room has a capacity of five tons of ice. On one side of this room is erected

Fig. 3. Two eight ton refrigerating machines in parallel.

Fig. 4. One-quarter ton refrigerating machine and ice-box.

a double pipe brine cooler, which rapidly chills to zero F. the brine for circulation through the ice cream machines. The temperature of this room is usually about 23 deg.

A restaurant naturally must use some ice. A machine hardly fills the bill for iced tea, lemonade, etc., at least not yet. Several years ago Horn & Hardart became convinced that more of the ice they paid for was lost through melting to waste than was actually used. In each of their restaurants they have installed a small Brunswick machine of quarter ton capacity, to keep their ice from melting. It saves them money. Incidentally it helps cool the food stored in the same box. (See Fig. 4.)

Mr. M. is a confectioner and ice cream maker, enjoying a large retail trade. He uses one ice cream machine, turning out forty quarts at a batch and makes from 200 to 800 quarts per day. The average production during the time covered by this record has been 400 quarts per day, six days a week. The larger portion is sold and served in his parlors, although considerable is sent out on orders. This necessitates the use of some salt and ice. It is a disputed question under such circumstances whether it pays to buy this amount of ice or to put in a plant large enough to make the small quantity which will be required. Leaving occasional unusual conditions out of consideration, it may be stated as a fact that where ice can be purchased for $3.50 or less per ton, there is no economy in making one's own supply. (See Fig. 5.)

The equipment here consists of a two-ton refrigerating machine, belt-driven by a 5 H.P. 2-phase General Electric motor. It is operated nine to fifteen hours per day and cools a large body of brine in a tank 8½′ long 2½′ wide and 3½′ deep sunk in the floor of the basement. Space was at a premium even before the machine was installed, so for the brine tank the cellar floor was excavated and the top of this tank made flush with the floor. The ammonia expansion or coiling pipes are situated in this tank. There is also a brine cooler here, the object of which is to rapidly cool a small portion of the brine just before it is carried out to the ice-cream machine. The brine is circulated from this tank by a No. 5 Gould rotary pump (shown white to the right and below the center of the illustration) to three ice-cream cabinets, two in the basement for storage; one, the serving cabinet, up in the store. Two of these are each 6′ long 2½′ wide and 2½′ deep and hold twelve 40-quart cans of ice cream. The serving cabinet holds

twelve cans of different sizes, is well insulated and fitted with a movable top, so that the cans can be lifted out when cleaning is necessary. The third cabinet holds twelve 20-quart cans, making the entire storage capacity equal 950 quarts. These are each on a separate circuit of the brine piping, which branches just beyond the pump. Each line carries a check valve to prevent back flow. The refrigerating machine is operated nine to fifteen hours daily, depending on the weather and amount of ice-cream

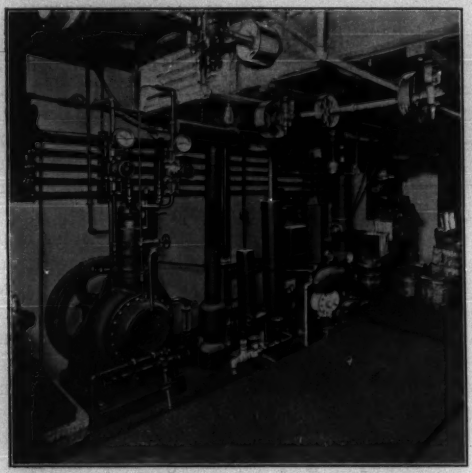

Fig. 5. Two ton refrigerating machine and brine pump. Note cover of the brine-tank in foreground.

made. The brine is kept normally at 4° to 8° F. It is generally brought down to the lower figure at night just before shut down, and in the morning the temperature will have risen to 9° or 10°.

The pipe and cabinets are all well insulated and the heat leakage kept at a minimum. This installation has been in operation during two summers and has proven its worth. Let us glance at some figures.

The cost of operation for three summer months stands as follows:

| | |
|---|---|
| Ice, 112 tons, at $3.00 | $336.00 |
| Salt, 560 bushels, at .35 | 196.00 |
| Electric power, oil fuses, etc. | 227.61 |
| Interest and depreciation | 81.25 |
| Repairs | 5.00 |
| | $845.86 |

Compare these with the cost for a similar period before the machine was introduced:

| | |
|---|---|
| Ice, 208 tons, at $3.00 | $624.00 |
| Salt, 1200 bushels, at .35 | 420.00 |
| Electric power | 104.76 |
| Labor, one man, $40 | 120.00 |
| | $1268.76 |

Saving in first summer, $422.90.

The item of $5.00 for repairs charged above is inserted to be conservative. As a matter of fact there were no repairs. At the end of the year the machine was overhauled as a matter of precaution, and a charge of $20 incurred. It must not be supposed that the full year will show a saving proportionate to these three months. There are many reasons why it does not, such as labor, change of business from parlor serving to delivery, efficiency of machinery at reduced load, etc. The entire year shows less than twice this figure, but even that is a pretty good investment.

And this is not all. There is probably no business where wet floors and general dampness are more unavoidable or more unhealthy than this, where salt and low temperature must be used. Artificial refrigeration does away with it. This alone should promote its adoption, and when the new dry insulated ice cream carriers become more widely known and used, the ice-cream man will have reached his ideal.

It is our opinion that the near future will show a rapid development in the use of refrigeration equipment for apartment houses and for drinking water systems in office buildings, schools, and public institutions of all kinds. Installations of this character have been used and have proven their value. An apartment house in Chicago has, for ten years, been furnishing ice and refrigeration service from one large centralized plant to ice boxes in each of its one hundred apartments, with very satisfactory results. Flat houses in our city now in contemplation include similar equipment in their plans.

Individual machines suitable for apartments or large residences are in the market and make a very neat and compact arrangement, which allows us to ignore the ice man and his troubles. An electric motor of one horse power size is all that is

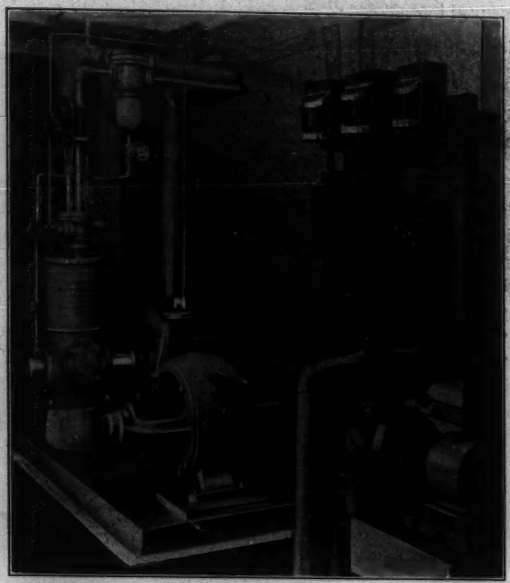

Fig. 6. Small Larsen-Baker machine for cooling drinking water. Pump at the right circulates the water through the building. Each has its individual motor.

needed. The machine is rated as one-quarter ton or one-eighth ton, and will make a small cake of ice for table use as well as keep the box cold. (See Fig. 7.)

Many office buildings are equipped with a cold drinking water system which saves a great amount of running up and down carrying ice every morning. (See Fig. 6.) This illustration shows the machine in the building of the Philadelphia Elec-

tric Company which performs this service. It is a two-ton Larsen-Baker outfit, and will cool enough water for two or three times the number of people it now supplies. The expansion coils are submerged in a tank of filtered water and cools it to the desired temperature, usually about 40°. Prevalent popular sentiment calls for drinking water freezing cold. This is a great mistake, and nine out of ten people would pronounce 45°

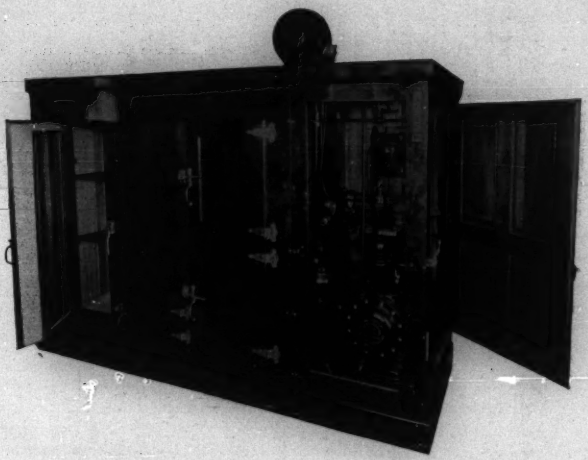

Fig. 7. Brunswick residence type refrigerating outfit and box complete with electric motor.

quite cold enough if unaware of the actual thermometer temperature. From the cooling tank the water is circulated through the building by a small rotary pump, which runs constantly during office hours. The refrigerating machine runs only a few hours out of the twenty-four.

The accompanying table gives figures taken from actual experience and shows the amounts of power used for artificial refrigeration in several lines of business.

| | Tons | H.P. | Notes | Kilowatt Hours. Yearly L. F. | Total year | Monthly Ave. | Largest Month. | Smallest Month. | Summer Mon. Ave. | Winter Mon. Ave. | Spring & Fall Ave |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dairy | 15 | 30 | | 48.4% | 33351 | 2779 | 5293 July | 00 Feb. | 4801 | 503 | 3034 |
| Dairy | 3 | 7 | 5 H.P. motor on bottle washer included. | 56.1% | 15463 | 1288 | 2294 July | 173 Dec. | 2069 | 292 | 1505 |
| Residence | ¼ | 1 | | 47.5% | 1112 | 93 | 141 July | 42 Feb. | 135.6 | 61.5 | 83.4 |
| Saloon | 3 | 7½ | 1 H.P. motor on brine pump included. | 62.5% | 12438 | 1036 | 1383 Sept. | 648 Feb. | 1288 | 677 | 926 |
| Soda Fountain | 3 | 7½ | ½ H.P. motor on pump included | 61 % | 11428 | 952 | 1318 Aug. | 713 Jan. | 1050 | 842 | 964 |
| Hotel | 4 | 10 | 1 H.P. motor on brine pump included. | 101 % | 25500 | 2125 | 2760 Aug. | 1663 Feb. | 2604 | 1687 | 2084 |
| Ice Cream | 2 | 5 | 7 H.P. motor on pump and ice-cream machine included. | 54.5% | 15008 | 1250 | 2023 Aug. | 975 Jan. | 1830 | 1164 | 126 |
| Meat Dealer | 1 | 3 | ½ H.P. motor on meat chopper included. | 48.3% | 3955 | 329 | 731 July | 1 Feb. | 706 | 56 | 226 |
| Meat, wholesale | 35 | 50 | | 107.9% | 123906 | 10325 | 28492 July | 0 Feb. | 23021 | 1977 | 5978 |
| Florist, wholesale | 6 | 12 | | 40 % | 11046 | 920 | 1419 June | 580 Jan. | 1190 | 618 | 953 |
| Butcher | 6 | 15 | 2 H.P. motor on meat chopper included. | 26 % | 9275 | 773 | 1755 July | 155 Feb. | 1604 | 208 | 700 |
| Florist | 1 | 3 | | 72.6% | 5103 | 425 | 505 July | 311 Feb. | 465 | 334 | 381 |

And now I want to say a few words about insulation. Get good insulation. This is paramount. Insulation on a refrigerator is like your clothing in winter. It is all very well to have an abundance of energy and life in your body, but if it is not suitably covered, "Jack Frost" will in the end prevail. So with cooled compartments, pipes, cabinets and ice chests. Here is your small, comparatively so, be it ever so large, refrigerated space and all around is nature's heat fighting to get in and equalize the temperature. Now, the greater the barrier, the better the insulation, the easier is it to keep out the heat. One might have ever so good a machine and be able to remove the heat from a refrigerator very expediciously, but if more heat is constantly leaking in, the machine will have to operate just that much longer, and *that* is the work which costs the money in artificial refrigeration. That is the *continual* expense while outlay for insulation occurs but *once* and brings big returns when done well.

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## ACETYLENE RULES MODIFIED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS.

The rules formulated by the National Board of Fire Underwriters for the acetylene industry have hitherto required outside installation of acetylene generators, and while, as a matter of fact, in by far the largest part of the United States this rule has not been insisted upon, in certain limited sections it has been rigidly enforced.

The existence of a rule prohibiting the installation of an acetylene generator in an insured building was a constant menace and handicap to the industry, and its enforcement in some sections and not in others placed insurance companies in the inconsistent position of insuring property in one State under conditions which it would not accept in another. An investigation by the National Board, as to the exact condition of the industry, disclosed the fact that, in those sections where inside installation had been permitted, acetylene was proving itself to be a safer illuminant than those which it replaced.

The National Board of Fire Underwriters, at its Executive Committee meeting on January 30th, 1908, held in New York City, after considering the various favorable reports submitted to it by its various committees, amended the rules covering the installation and use of acetylene generators by striking out such words as prohibited inside installation under all conditions and substituted the following: "Generators, especially in closely built up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9."

It will be seen at once that while the National Board recommends outside installation as being ideal, in place of the absolute prohibition, the rules now mean that in all outlying districts generators may be placed in-

side, but in closely built up districts it recommends outside installation as its preference.

Even where outside installation is preferred the rule regarding construction of generator houses has been modified, and where such houses formerly had to be fire-proof, constructed of brick and located as far as practicable from other buildings, such houses may now be located adjoining an insured building and fire-proof construction is not required.

It will be seen that the above modifications are radical and are a most favorable indication of the fact that inventive genius and a close adherence to the rules of the National Board of Fire Underwriters have received a deserved recognition.

The acetylene industry has been subject to the rules of the National Board from its inception, and has loyally endeavored to meet all insurance requirements, not only in letter but in spirit. The result has been a vast expansion of the industry and a growing safety of the illuminant until the above modifications were deemed warranted by the National Board.

The investigations which were set on foot for the purpose of ascertaining facts brought forth the conclusion that, in view of the fact that the number of acetylene generators installed inside of buildings had very largely increased in the past few years, while, at the same time, the fire records seemed to show that the number of fires ascribed to such installations had if anything decreased, the rules of the National Board covering the construction and installation of acetylene apparatus had apparently safeguarded the hazard to a great extent.

The fact was demonstrated that acetylene illumination generally replaces methods which entail an equal if not a greater hazard.

Consideration was given to the fact that outside installation of acetylene generators was frequently impracticable on account of climatic conditions.

The facts disclosed by the investigation made a modification of the rules inevitable, and it was agreed that the time had arrived when the rule as to outside installation might be properly modified so that it would recommend outside location as being the ideal location, yet permitting, under proper restrictions, the location of the generator inside of an insured building.

The rules of the National Board are not mandatory, and in some sections of the country the rule regarding outside installation was not followed, but in certain sections of the country, notably New England, Suburban Philadelphia, and the Southeastern States, this rule was enforced. Some manufacturers of generators were therefore brought into competition with inferior generators, which had not the approval of the National Board of Fire Underwriters, and as both the permitted generator and the unpermitted generator must be put outside, if the rule was enforced, the competition was of such a nature that the manufacturer of a first-class generator had difficulty in surviving.

The modification of the rule will undoubtedly give a distinct advantage to the manufacturer of a permitted generator, and will draw the industry into closer alliance and loyal adherence to the excellent rules of the National Board. This relief and additional advantage to the manufacturer of a good generator means undoubtedly the practical elimination of what is known in the trade as the "tin-can generator," which, by the way, it is authoritatively stated has been the cause of eighty-five per cent. of the troubles which have arisen from the use of acetylene.

If the industry understands clearly the tremendous advantage which will accrue to it from a most careful and painstaking adherence to the requirements of the Underwriters, it will benefit in the future from the supervision of the National Board as it has in the past.

To-day the acetylene industry is one of the few commercial organizations which has been big enough to realize the advantages of laying a broad foundation on quality by accepting the suggestions of the insurance engineers, and the rapid advance of acetylene as an illuminant is largely due to the intelligence with which it has grasped the subject.

## Section of Physics and Chemistry.

### Explosives.

### The Progressive Decomposition of Gun-Cotton During Its Storage.

By M. M. O. Silberrad and R. C. Farmer.

(Zeitschrift für Schiess und Sprengstoffwesen, 1907, p. 61.)

Translated from the Moniteur Scientifique of January, 1908,

By W. J. Williams, F.I.C.

The spontaneous decomposition of explosives with a nitric ester base begins at the ordinary temperature, in distinction to what takes place with true nitro-substitution compounds, such as picric acid. The progressive course of this decomposition has not yet been the object of systematic research, therefore we have undertaken certain experiments in this direction; experiments which have been to some extent made on a grand scale, using several hundred kilograms of explosives. They were carried out at different temperatures in large thermostats at constant temperature. The access of humidity, which exerts a *very* great influence on the decomposition, has been varied by different means. These researches have given the following results:

1. Physical modifications produced during storage. The ex-

terior indications of decomposition are not apparent, as a rule, until it has progressed to such a point that no conclusion can be drawn as to the degree or extent of the decomposition. The most characteristic points as to the decomposition of gun-cotton are:

a. The odor of nitrogen dioxide; if residues of ether and alcohol are present, the odor of ethyl nitrite is also apparent.

b. The action of the oxides and acids of nitrogen is shown on the wrappers, in this sense that the silk paper envelope of the cartridges is strongly attacked. Oiled paper behaves similarly, The sulphur contained in rubber (caoutchouc) wrappers is converted by the nitrogen oxides into sulphuric acid. which greatly accelerates decomposition. This is the reason why wrappers of this kind should not be used.

c. The appearance varies greatly with the conditions of storage. Sheets of gelatinized (colloided) nitro-cellulose stored in dry air curl up little by little, become brittle, and porous on their exterior, and streaks appear on their surfaces. In proportion as the decomposition progresses the color deepens strongly and sometimes becomes almost black. In moist air, deliquescent acid products are produced by hydrolysis, which make the surface glutinous, and greedily attract water. The interior of these pieces changes finally to a semi-crystalline nucleus, composed essentially of oxalic acid. On the surface the gun-cotton loses its explosive properties little by little, and burns with great difficulty leaving an interior and exterior annular ring of incombustible matter. Although these phenomena appear to a certain degree in dry air, they are more especially observable in moist air.

2. The influence of storage on the chemical composition is shown by the following changes:

a. The material suffers a progressive but constant loss of weight, which is not caused by the volatilization of the residual volatile solvents, for their value in percentage does not change. This loss is chiefly due to the decomposition of the nitric esters.

b. The content of nitrogen suffers a proportional diminution from the formation of nitrogen oxides which are set free.

c. The proportion of nitro-cellulose, soluble in ether-alcohol, increases while the proportion of insoluble nitro-cellulose decreases simultaneously. The reason of this is that the decomposition produces compounds soluble in ether-alcohol.

d. The slight increase of the residue insoluble in acetone is similarly due to the formation of products of decomposition in solution is acetone and not to the re-transformation of nitro-cellulose back to cellulose.

e. Water extraction furnishes a means of measuring the degree of decomposition of gun-cotton; for the products of decomposition are for the greater part soluble in water, as Silberrad and Farmer have recently shown.*

f. The heat test gives figures lower and lower proportionately as the decomposition progresses; however the coloration of the reagent paper may have been produced by acid bodies already formed before the heat test commenced.

3. The speed of decomposition is increased by the nitrogen oxides formed during the actual decomposition, that is to say, this is a case of auto-catalysis. This fact is clearly shown by the following figures which show the percentage loss of nitrogen for each three months' period of storage.

4. The degree of humidity of the atmosphere plays a great part both as to the speed and as to the nature of the decomposition. Other things being equal the decomposition is far more rapid in a damp atmosphere. In so far as concerns the nature of the decomposition, in the presence of moisture and on account of hydrolysis, hygroscopic oxy-acids are formed which make the inflammation of the powder so difficult, that in such a case it is hardly possible to have spontaneous ignition.

5. The influence of humidity again makes itself felt by falsifying the results of the heat test. The nitrogen acids, which are easily formed by the action of water, react on the test-paper even when the powder is entirely unchanged, at least so far as its ballistic results are concerned. This fact has been verified by experiments (see table 26). But even when the ballistic properties are changed, the powder does not show any tendency to ignite spontaneously. In this respect the decomposition set up in the presence of water is of little danger, but it should be prevented as far as possible, on account of the great speed with which it progresses, and which greatly reduces the time during which the powder is effective.

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*Jour. Chem. Soc., 1906, p. 89 and 1182.

LOSS OF THE PERCENTAGE OF NITROGEN OF THE NITRO CELLULOSE.

| | Variation in the proportion of nitrogen. Experim't at 60°C. in dry air. | | Experim't at 49°C. in damp air. | |
|---|---|---|---|---|
| | 1st period of 3 mos. | 2d period of 3 mos. | 1st period of 3 mos. | 2d period of 3 mos. |
| Nitro cellulose powder No. 53 | −0.1 | −0.5 | — | — |
| " " " " 62 | — | — | +0.2 | −3.9 |
| " " " " 63 | 0.0 | −0.5 | 0.0 | −0.1 |
| Flameless " " 72 | −0.1 | −2.0 | −0.4 | −4.7 |
| " " " " 73 | −0.3 | −3.0 | −1.9 | — |
| Pyro-collodion | −0.2 | −0.9 | −2.3 | −3.9 |
| " " for 6″ R.F. guns | −0.1 | −0.5 | −2.9 | −4.0 |
| " " for 4″ R.F. guns | −0.3 | −0.6 | −1.2 | −3.9 |
| " " for 8″ guns | 0.0 | −0.2 | −0.1 | −1.7 |

6. The influence of temperature is extremely great. Experiments have shown that the speed of decomposition is doubled for each rise of temperature of 5°C. Hence a powder stored at 40° C. should be examined sixteen times as often as powder stored at 20°C. to obtain the same degree of security. Powders that have been manufactured according to modern rules and precautions can be stored practically for an indefinite time at temperatures below 15°C.

## EXPERIMENTAL PART.

*Method of Storage.*—To approach as nearly as possible the conditions in force at powder factories, powders should be stored in magazines kept at a constant temperature. To remain unaffected by the position of the heating arrangements and to protect the magazines from their reciprocal influence, the localities are isolated from each other and surrounded by mounds of earth. Each magazine consists of a room lined internally with zinc and covered externally with a convenient thickness of some material insulating from heat. The chambers are covered with thin plates of corrugated iron. There is a passage-way between each two. The dimensions are—

Length.....2.40 meters.
Breadth.....1.40 " (occasionally 2 meters).
Height.....2.80 "

The chambers contain little bullseyes (peep-holes) of double glass, corresponding to the outside windows, which permit the

reading of the temperature shown by the thermometers placed inside. The reading is made from outside with the help of a lens. The cold chamber, kept at —18°C., was of the same internal dimensions, but was lined with a thicker insulating bed (30 centimeters of pieces of wood charcoal).

The heating was done by steam-coils, generally in a dry atmosphere. In some experiments the air was saturated with moisture by placing the heating coils in a vessel of water and introducing some of the steam (vapor) directly into the rooms.

The exact regulation of the temperature of such large thermostats was naturally attended with considerable difficulties. It was finally effected by a steam valve and an electro magnet. The heating was done by a principal steam-pipe and by a second smaller pipe, in which the steam circulated independently of the first pipe, and on which the regulating valve was placed. The principal pipe was not quite sufficient to keep the desired temperature, and under normal conditions the valve of the smaller pipe was a trifle wider open than was necessary to maintain the desired temperature. Under these conditions, it is easily understood that all that is necessary is to have an automatic arrangement which closes the valve of the small pipe when the temperature is too high, and reopens it when it falls. This arrangement consists of a thermometer with a spiral-shaped reservoir filled with mercury and placed in the chamber; when the temperature rises too high, the mercury closes an electrical circuit of low voltage which starts a small relay. This relay closes the principal current in which the electromagnet stands. The motion imparted to the iron core of the electro magnet is multiplied by a lever and transmitted to the steam-valve which closes itself. The temperature falls a little, then the same action re-commences in inverse order. By this means the temperature can be kept constant to approximately $\pm$ 1°C. The use of a relay is necessary, for the thin column of mercury can only carry a very weak current quite insufficient to start the electro-magnet.

Granting that smokeless powders are constituted of a colloidal mixture of different nitric ethers and cellulose, it is inevitable that they should show differences of composition in their mass, no matter how great care is taken to thoroughly mix the gelatinized mass. To give an idea of the consequent uncertainty as to the composition, which exercises an enormous influence on the results

of these storage experiments, different pieces of the same powder were analyzed, and even different parts of the same piece. A nitro-cellulose was chosen moulded in tubes of 8.75 m/m in diameter, and pieces with as much external difference as possible were taken. Control analyses were made from samples taken from the two extremities of the same piece.

The results of these analyses are given in the following tables, Nos. 1 and 2.

It will be noticed that the different ends of the same tube are generally identical. Different tubes, however, sometimes present notable differences. In spite of this circumstance, to draw exact conclusions from these storage experiments, each analysis should be made on a well-chosen average sample.

Experience has shown that the best way of choosing a fair average sample is as follows: A bundle of tubes is taken, sufficient in quantity to make all the analyses required in the course of the experiment, by tying together a certain number of sticks of nitro-cellulose powder. The end of these tubes is sawn off, as a sample of the material which has not been heated, the remainder is placed in the magazine with the rest of the lot. When the experiment is ended, an equal length is sawn off for analysis. Thus comparable results are obtained.

## ANALYTICAL RESULTS.

*A. Experiments on the Large Scale.*—The figures given in tables I to VII were obtained from experiments carried out on very large quantities of colloided powder stored in the magazines above described. The results are reported on the substance free from ash.

The proportion of volatile constituents was determined on finely powdered material, air-dried. The volatile matter was determined by the loss of weight after twenty-four hours' dessication at 80°C. The nitrogen was determined by Lunge's method (nitrometer.) The aqueous extract was obtained by extracting the powdered substance with boiling water for one hour in a Soxhlet apparatus. The aqueous solution was then evaporated and the residue dried to 80°C. to constant weight. All the figures reported are the mean of two concordant results.

VARIATIONS IN THE COMPOSITION OF COLLOIDED NITRO-CELLULOSE.

| | Percentage of sample taken | | | | | | Percentage of sample taken | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clear tubes. | | Average. | | Dark. | | Clear tubes. | | Average. | | Dark. | |
| Insoluble in ether alcohol.. | 7.82 | 7.72 | 6.84 | 6.20 | 12.80 | 13.10 | 8.05 | 7.93 | 6.91 | 6.44 | 13.80 | 13.61 |
| Soluble " " .. | 89.0 | 89.25 | 89.29 | 89.71 | 82.89 | 82.38 | 91.58 | 91.68 | 92.86 | 93.25 | 86.12 | 85.55 |
| Insoluble in acetone..... | 0.36 | 0.38 | 0.22 | 0.29 | 0.56 | 0.82 | 0.37 | 0.39 | 0.23 | 0.31 | 0.58 | 0.84 |
| Volatile constituents..... | 2.82 | 2.65 | 3.65 | 3.80 | 3.75 | 3.70 | | | | | | |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 (Sic) | 100.00 |
| Nitrogen ..... | 11.98 | 12.05 | 11.92 | 11.86 | 11.79 | 11.80 | 12.34 | 12.38 | 12.38 | 12.43 | 12.25 | 12.26 |
| Ash ..... | 1.02 | 1.87 | 0.60 | 0.72 | 0.73 | 0.78 | 1.05 | 0.89 | 0.89 | 0.75 | 0.76 | 0.81 |

## TABLE III.

### NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL.

Exposed 12 hours daily to moist air at 46°C. Tubes 77 c/m long, 8.75 m/m external diameter, and 3.55 m/m internal diam.

| How Stored. | Quantity. | Duration of storage. | Heat test at 82.8°C. minutes | Loss of weight. | Results of analysis. | Soluble in ether alcohol. | Insoluble in ether alcohol. | Insoluble in acetone. | Aqueous extract. | Volatile constituents. | Nitrogen. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Before storage | 26 | —— | % on original material. | 85.58 | 10.18 | 0.42 | 0.20 | 3.82 | 11.90 |
| | | | | | % on dry material. | 88.97 | 10.59 | 0.44 | 0.21 | —— | 12.32 |
| Tin cases hermetically soldered. | Small lot | 6 mos. | 7 | 0.44 | % on original material. | 89.15 | 6.77 | 0.64 | 1.02 | 3.44 | 11.67 |
| | | | | | % on dry material. | 92.33 | 7.01 | 0.66 | 1.05 | —— | 12.09 |
| Iron cases hermetically sealed. | 78.5 k.g. | 6 mos. | 4 | 0.36 | % on original material. | 88.32 | 7.44 | 0.72 | 1.92 | 3.52 | 11.94 |
| | | | | | % on dry material. | 91.55 | 7.71 | 0.74 | 1.90 | —— | 12.38 |
| In wooden cases. | 94 k.g. | 6 mos. | ¾ | 0.32 | % on original material. | 86.06 | 7.31 | 2.37 | 2.69 | 4.26 | 11.38 |
| | | | | | % on dry material. | 89.89 | 7.63 | 2.48 | 2.81 | —— | 11.89 |
| Open to the air. | 78.5 k.g. | 6 mos. | ¾ | 0.40 | % on original material. | 89.59 | 5.64 | 0.74 | 1.81 | 4.03 | 11.81 |

TABLE I.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | material. | | | | | | | |
| | | % on dry material. | —— | —— | 0.36 | —— | 12.20 | —— | —— |

(4) Storage in dry air at 54.4°C. Weight 251 kilograms. Stored in wooden cases with a wrapper of silk tissue and rubber.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Not heated | 0 | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | After storage the tubes ly of nitrogen oxides and of ethyl nitrite. |

TABLE II.

NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL.

Tubes 105.5 c/m long, 13.6 m/m external diameter, and 6.20 m/m internal diameter.

(1) Storage at 54.4°C. in dry air. Powder exposed to the air without packing.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Not heated | —— | % on original material. | 80.92 | 14.24 | 0.45 | 4.39 | 11.78 | —— | 56 |
| | | % on dry material. | 84.92 | 14.90 | 0.47 | —— | 12.32 | —— | —— |

## TABLE III.

### NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL.

Exposed 12 hours daily to moist air at 46°C. Tubes 77 c/m long, 8.75 m/m external diameter, and 3.55 m/m internal diam.

| How Stored. | Quantity. | Duration of storage. | Heat test at 82.8°C. minutes | Loss of weight. | Results of analysis. | Soluble in ether alcohol. | Insoluble in ether alcohol. | Insoluble in acetone. | Aqueous extract. | Volatile constituents. | Nitrogen. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Before storage | 26 | —— | % on original material. | 85.58 | 10.18 | 0.42 | 0.20 | 3.82 | 11.90 |
| | | | | | % on dry material. | 88.97 | 10.59 | 0.44 | 0.21 | —— | 12.32 |
| Tin cases hermetically soldered. | Small lot | 6 mos. | 7 | 0.44 | % on original material. | 89.15 | 6.77 | 0.64 | 1.02 | 3.44 | 11.67 |
| | | | | | % on dry material. | 92.33 | 7.01 | 0.66 | 1.05 | —— | 12.09 |
| Iron cases hermetically sealed. | 78.5 k.g. | 6 mos. | 4 | 0.36 | % on original material. | 88.32 | 7.44 | 0.72 | 1.92 | 3.52 | 11.94 |
| | | | | | % on dry material. | 91.55 | 7.71 | 0.74 | 1.90 | —— | 12.38 |
| In wooden cases. | 94 k.g. | 6 mos. | ¾ | 0.32 | % on original material. | 86.06 | 7.31 | 2.37 | 2.69 | 4.26 | 11.38 |
| | | | | | % on dry material. | 89.89 | 7.63 | 2.48 | 2.81 | —— | 11.89 |
| Open to the air. | 78.5 k.g. | 6 mos. | ¾ | 0.40 | % on original material. | 89.59 | 5.64 | 0.74 | 1.81 | 4.03 | 11.81 |

## TABLE VII. (Sic.)

NITRO-CELLULOSE COLLOIDED WITH ETHER-ALCOHOL STORED AT 45.5°C. IN A DRY ATMOSPHERE.

The results are the mean of concordant experiments.

| Dimensions of tubes in glass | | | | Time of Storage in months | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length | External dia. | Internal dia. | | 0 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 |
| cm. | mm. | mm. | Zinc iodide test at 80°C (min.) | 30 + | 45 | 50–60 and more | 48 | 24 | 25 | 39 | 46 | 34 |
| 230 | 4.5 | 3.0 | Ignition test in °C | 176¼° | 176¼° | 176½° | 178¼° | 176¼° | 175° | 176¼° | 175½° | 176½° |
| | | | Nitrogen % | 11.75 | | | | | | | | 11.73 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 9 | 60 + | 60 + | 60 + | 4 | 5 | 7 | 4 |
| 785 | 12.5 | 4.5 | Ignition test | 177¼° | 177½° | 177° | 173¼° | 177¼° | 175½° | 175¼° | 175½° | 176° |
| | | | Nitrogen % | 12.38 | | | | 12.36 | | | | 12.32 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + |
| 128 | 4.0 | 1.5 | Ignition test | 175¼° | 173½° | 173½° | 173½° | 175¼° | 175¼° | 176¼° | 174¼° | 174½° |
| | | | Nitrogen % | 12.43 | | | | 12.25 | | | | 12.42 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 10 |
| 126.7 | 2.6 | 0.7 | Ignition test | 176° | 175½° | 175° | 176¼° | 177° | 177° | 177° | 176° | 175¼° |
| | | | Nitrogen % | 12.28 | | | | 12.24 | | | | 12.38 |

### B. EXPERIMENTS ON STORAGE IN A DRYING-ROOM (OVEN).

If the preceding results are compared with those obtained when working on small quantities, it is evident that 100 grams give sufficiently exact results. Consequently powder has been effectively stored in boxes of 100 grams, kept at a constant temperature in a dry-house, that is to say:—

(1) At 60°C. in dry air,

(2) At 49°C. in moist air.

The temperature was maintained constant to about 1°C. by means of Scheibler's regulator.

The choice of samples was made as has been previously described. In the case of tests made in moist air, the bundle of tubes was undone after the test and the powder was dried for twenty-four hours at 38°C. before being weighed. We only reproduce here some of the twenty-five tables contained in the original work.

TABLE I.

NITRO-CELLULOSE COLLOIDED BY ETHER ALCOHOL.

(Tubular rods 77 c/m long, 8.75 m/m external diameter, and 3.55 m/m internal diameter.

(1) Storage at—18°C. Quantity stored 313 kilograms. Cartridges 15.2 c/m long, wrapped in silk tissue, in wooden cases.

| Time of storage or heating. | Loss of weight during storage in %. | | Soluble in ether alcohol. | Insoluble in ether alcohol. | Insoluble in acetone. | Volatile constituents. | Content of nitrogen. | Aqueous extract. | Heat test (minutes) at 82.8°C. | Physical properties. |
|---|---|---|---|---|---|---|---|---|---|---|
| Not heated | —— | % on original material. | —— | —— | 0.42 | 3.82 | 11.85 | 0.20 | 26 | No visible change. |
| | | % on dry material. | —— | —— | 0.44 | —— | 12.32 | 0.21 | — | |
| 6 months | —— | % on original material. | —— | —— | —— | 3.55 | 11.80 | —— | 21 | |
| | | % on dry material. | —— | —— | —— | —— | 12.23 | —— | — | |
| (2) Storage in dry air at 38°C. Weight 720 kilograms. Cartridges 15.2 c/m. Wrapped in silk tissue, in wooden cases. | | | | | | | | | | |
| Not heated | —— | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | Slight modification of the physical properties. The black silk tissue not attacked. Faint smell of ethyl nitrite. |
| | | % on dry material. | 88.97 | 88.97 (Sic) | 0.44 | | 12.32 | 0.21 | — | |
| 4½ months | —— | % on original material. | —— | —— | —— | 2.99 | 11.91 | —— | 13 | |
| | | % on dry material. | —— | —— | —— | —— | 12.28 | —— | — | |
| 9 months | —— | % on original material. | —— | —— | —— | 3.31 | 11.73 | —— | 5 | |
| | | % on dry material. | —— | —— | —— | —— | 12.13 | —— | — | |
| 10½ months | —— | % on original material. | —— | —— | —— | 3.29 | 11.71 | —— | 2 | |
| | | % on dry material. | —— | —— | —— | —— | 12.10 | —— | — | |
| 12 months | 6.75 | % on original material. | 86.91 | 86.91 (Sic) | 0.63 | 3.13 | 11.41 | 0.55 | 3 | |
| | | % on dry material. | 89.72 | 89.72 (Sic) | 0.65 | —— | 11.77 | 0.57 | — | |
| (3) Storage in dry air at 49°C. Weight 251 kilograms. Cartridges 15.2 c/m. Wrapped in silk tissue. | | | | | | | | | | |
| Not heated | Reported 0 | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | The external aspect suffered no important change during storage. A faint smell of ethyl nitrite. |
| | | % on dry material. | 88.97 | 10.50 | 0.44 | —— | 12.32 | 0.21 | — | |
| 3 months | 1.93 | % on original material. | 86.08 | 10.17 | 0.37 | 3.38 | 11.90 | —— | 8 | |
| | | % on dry material. | 89.10 | 10.52 | 0.38 | —— | 12.32 | —— | — | |
| 6 months | 2.40 | % on original material. | —— | —— | 0.35 | 3.15 | 11.87 | —— | 9 | |
| | | % on dry material. | —— | —— | 0.36 | —— | 12.20 | —— | — | |
| (4) Storage in dry air at 54.4°C. Weight 251 kilograms. Stored in wooden cases with a wrapper of silk tissue and rubber. | | | | | | | | | | |
| Not heated | 0 | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | After storage the tubes became brittle and porous. Their color varied from yellow to dark brown. A smell of nitrogen oxides and of ethyl nitrite. |
| | | % on dry material. | 88.97 | 10.59 | 0.44 | —— | 12.32 | 0.21 | — | |
| 4½ months | —— | % on original material. | —— | —— | —— | 2.96 | 11.81 | —— | 2 | |
| | | % on dry material. | —— | —— | —— | —— | 12.17 | —— | — | |
| 10½ months | —— | % on original material. | 87.64 | 7.03 | 1.77 | 3.56 | 11.37 | —— | — | |
| | | % on dry material. | 90.87 | 7.30 | 1.83 | —— | 11.18 | —— | — | |
| 12 months | 9.46 | % on original material. | 89.63 | 3.37 | 2.36 | 4.64 | 10.08 | 11.53 | ¾ | |
| | | % on dry material. | 94.00 | 3.53 | 2.47 | —— | 10.56 | 12.08 | — | |

(5) Storage at 54.4°C. in moist air. Weight 272 kilograms. Packed in 100 lb. cases. Packed in oiled paper with a rubber wrapper.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Not heated | | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | At the end of 5¼ months the powder became glutinous on the surface and strongly acid. That placed in the upper part had lost most of its nitrogen and burned with difficulty leaving a carbonaceous residue. |
| | | % on dry material. | 88.97 | 10.59 | 0.44 | —— | 12.32 | —— | — | |
| 3 months | —— | % on original material. | 86.63 | 9.87 | 0.38 | 3.62 | 11.90 | —— | 8 | |
| | | % on dry material. | 89.88 | 9.72 | 0.40 | —— | 12.34 | —— | — | |
| 5¼ months | —— | | —— | —— | —— | 3.32 | 11.19 | 3.90 | — | |
| | | | —— | —— | —— | —— | 11.56 | 4.03 | — | |

(6) Storage at 60°C. in dry air. Weight 251 Kilograms. Packed in cases.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Not heated | | % on original material. | 85.58 | 10.18 | 0.42 | 3.82 | 11.85 | 0.20 | 26 | The powder ignited spontaneously one day after the last sample was taken. It gave 50.5% alcoholic extract on the original weight. No marked change in the physical properties at the end of 9 months, but in about 10¾ months, just before it ignited spontaneously, it became very brittle, and fell to dust on the slightest pressure. The tubes were yellow or black and smelled strongly of nitrogen oxides and of ethyl nitrite. |
| | | % on dry material. | 88.97 | 10.59 | 0.44 | —— | 12.32 | 0.21 | — | |
| 4½ months | —— | % on original material. | —— | —— | —— | 2.87 | 11.89 | —— | 1¼ | |
| | | % on dry material. | —— | —— | —— | —— | 12.24 | —— | — | |
| 9 months | | % on original material. | —— | —— | —— | 3.98 | 11.35 | —— | ½ | |
| | | % on dry material. | —— | —— | —— | —— | 11.81 | —— | — | |
| 10¾ months | 28.2 | % on original material. | 91.13 | 1.33 | 2.44 | 5.10 | 9.80 | 30.15 | in the cold | |
| | | % on dry material. | 96.03 | 1.40 | 2.37 | —— | 10.32 | 31.74 | — | |

## TABLE II.

### NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL.

Tubes 105.5 c/m long, 13.6 m/m external diameter, and 6.20 m/m internal diameter.

(1) Storage at 54.4°C. in dry air. Powder exposed to the air without packing.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Not heated | —— | % on original material. | 80.92 | 14.24 | 0.45 | 4.39 | 11.78 | —— | 56 |
| | | % on dry material. | 84.92 | 14.90 | 0.47 | —— | 12.32 | —— | — |
| 9 months | —— | % on original material. | 84.24 | 11.49 | 0.57 | 3.70 | 11.86 | —— | 1 |
| | | % on dry material. | 87.48 | 11.93 | 0.59 | —— | 12.31 | —— | — |

(2) Storage at 60°C in dry air. 420 kilograms of powder exposed to the air.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Not heated | | % on original material. | 80.92 | 14.24 | 0.45 | 4.39 | 11.78 | —— | 56 | The physical aspect of the nitro-cellulose after storage showed a slight decomposition. The tubes were a little twisted and porous. When broken they smelled of ethyl nitrite. The alcoholic extact at the end of 10¾ months was 12.76% of the original material. |
| | | % on dry material. | 84.63 | 14.90 | 0.47 | —— | 12.32 | —— | — | |
| 4½ months | —— | % on original material. | —— | —— | —— | —— | 11.80 | —— | 2 | |
| | | % on dry material. | —— | —— | —— | 3.16 | 12.19 | —— | — | |
| 6 months | | % on original material. | 85.21 | 11.09 | 0.51 | —— | 11.66 | —— | ½ | |
| | | % on dry material. | 88.02 | 11.46 | 0.52 | 3.19 | 12.04 | —— | — | |
| 10¾ months | 3.55 | % on original material. | 87.82 | 6.60 | 1.71 | —— | 11.45 | —— | ¾ | |
| | | % on dry material. | 91.34 | 6.87 | 1.79 | —— | 11.91 | —— | — | |

## TABLE IV.

NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL STORED IN DRY AIR AT 38°C

Tubes 77 c/m long, 8.75 m/m external diameter, and 3.55 m/m internal diameter.

| How stored. | Quantity. | Period of storage. | Heat test at 71.1°C. minutes. | Loss of weight. | Results of analysis. | Soluble in ether alcohol. | Insoluble in ether alcohol. | Insoluble in acetone. | Volatile constituents. | Nitrogen. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Before storage | 6 | —— | % on original material. | 84.28 | 11.59 | 0.55 | 3.58 | 11.99 |
| | | | | | % on dry material. | 87.41 | 12.01 | 0.57 | —— | 12.44 |
| Tubes in glass hermetically sealed with wax. | Small quantity. | 6 mos. | 4 | 0.056 | % on original material. | 87.75 | 8.37 | 0.78 | 3.10 | 11.75 |
| | | | | | % on dry material. | 90.56 | 8.64 | 0.80 | —— | 12.13 |
| In hermetically seal-iron cases. | 157 k.g. | 6 mos. | 6 | 0.348 | % on original material. | 86.21 | 10.90 | 0.42 | 2.47 | 11.83 |
| | | | | | % on dry material. | 88.39 | 11.18 | 0.43 | —— | 12 13 |
| In defective iron cases. | 157 k.g. | 6 mos. | 3 | 0.749 | % on original material. | —— | —— | 0.44 | 2.63 | 11.69 |
| | | | | | % on dry material. | —— | —— | 0.45 | —— | 12.00 |
| Packed in wood, with cover (lid) laid over. | 157 k.g. | 6 mos. | 5 | 1.58 | % on original material. | 85.36 | 11.62 | 0.57 | 2.45 | 11.65 |
| | | | | | % on dry material. | 87.51 | 11.91 | 0.58 | —— | 11.94 |

TABLE V.

NITRO-CELLULOSE COLLOIDED BY ETHER-ALCOHOL, STORED AT A CONSTANT TEMPERATURE OF 60°C. IN DRY AIR.

Tubes 72 c/m long, 7.84 m/m external diameter and 3.64 m/m internal diameter. Density before drying 1.584. Average weight of tubes 44.0 gr.

| How stored. | Quantity. | Period of storage. | Nitrogen %. | Ash %. | % of moisture on leaving storage. | Heat test at 85°C. minutes. | Time when brown fumes showed at 135°C. Minutes. |
|---|---|---|---|---|---|---|---|
| —— | —— | Before storage | 12.45 | 0.27 | 1.35 | 14 | 60+ |
| In closed cartridges. | 9 k.g. | 3 months. | 12.41 | —— | 1.28 | 13 | 60 |
| In open cartridges. | 9 k.g. | 3 months. | 12.37 | —— | 0.80 | 11 | 60 |
| In cartridges placed in an ordinary wooden box. | 9 k.g. | 3 months. | 12.33 | —— | 0.43 | 10 | 60 |

## TABLE VII. (Sic.)

NITRO-CELLULOSE COLLOIDED WITH ETHER-ALCOHOL STORED AT 45.5°C. IN A DRY ATMOSPHERE.

The results are the mean of concordant experiments.

| Dimensions of tubes in glass | | | | Time of Storage in months | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Length | External dia. | Internal dia. | | 0 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 |
| cm. | mm. | mm. | Zinc iodide test at 80°C (min.) | 30 + | 45 | 50–60 | 48 | 24 | 25 | 39 | 46 | 34 |
| | | | Ignition test in °C | 176¼° | 176¼° | and more 176½° | 178¼° | 176¾° | 175° | 176¼° | 175½° | 176½° |
| 230 | 4.5 | 3.0 | Nitrogen % | 11.75 | | | | | | | | 11.73 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 9 | 60 + | 60 + | 60 + | 4 | 5 | 7 | 4 |
| 785 | 12.5 | 4.5 | Ignition test | 177¼° | 177½° | 177° | 173¼° | 177¼° | 175½° | 175¼° | 175½° | 176° |
| | | | Nitrogen % | 12.38 | | | | 12.36 | | | | 12.32 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + |
| 128 | 4.0 | 1.5 | Ignition test | 175¾° | 173½° | 173½° | 173½° | 175¾° | 175¾° | 176¼° | 174¾° | 174½° |
| | | | Nitrogen % | 12.43 | | | | 12.25 | | | | 12.42 |
| | | | Zinc iodide test at 80°C (min.) | 30 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 60 + | 10 |
| 126.7 | 2.6 | 0.7 | Ignition test | 176° | 175½° | 175° | 176¼° | 177° | 177° | 177° | 176° | 175¼° |
| | | | Nitrogen % | 12.28 | | | | 12.24 | | | | 12.38 |

### B. EXPERIMENTS ON STORAGE IN A DRYING-ROOM (OVEN).

If the preceding results are compared with those obtained when working on small quantities, it is evident that 100 grams give sufficiently exact results. Consequently powder has been effectively stored in boxes of 100 grams, kept at a constant temperature in a dry-house, that is to say:—

(1) At 60°C. in dry air,

(2) At 49°C. in moist air.

The temperature was maintained constant to about 1°C. by means of Scheibler's regulator.

The choice of samples was made as has been previously described. In the case of tests made in moist air, the bundle of tubes was undone after the test and the powder was dried for twenty-four hours at 38°C. before being weighed. We only reproduce here some of the twenty-five tables contained in the original work.

TABLE XIX.

SMOKELESS POWDER IN OPEN CARTRIDGES (GERMAN).

Small crosses, not colloided. Greatest length 12 m/m. Peculiar smell, recalling that of alcohol.

| | Not Heated. | 3 mos. at 60°C., dry air. | 6 mos. at 60°C., dry air. | 3 mos. at 49°C., moist air. | 6 mos. at 49°C., moist air. |
|---|---|---|---|---|---|
| Physical changes. | —— | Appearance and smell practically unchanged. | Color a little clearer; no smell. | Appearance and smell practically unchanged. | No change; no perceptable smell of nitrogen peroxide. |
| Reaction with litmus paper | Neutral. | Paper red. | Paper red. | Paper discolored. | —— |
| Loss of weight %. | 0 | 3.69 | 4.96 | 1.57 | —— |
| Nitrogen on original material %. | 12.56 | 12.38 | 12.54 | 12.48 | 12.28 |
| On dry material %. | 12.66 | 12.50 | 12.65 | 12.58 | 12.53 |
| Aqueous extract % on original material %. | 1.58 | 1.58 | 1.80 | 1.08 | 2.83 |
| On dry material %. | 1.60 | 1.60 | 1.82 | 1.09 | 2.89 |
| Heat test at 71°C. Minutes. | 6 | 11½ | 4½ | 20 | 6½ |
| Ignition. Temperature °C. | 179° 179.5° | 184° 184° | 180.5° 180.5° | 184° 184.5° | 167° 168° |

## TABLE XXIV.

### PYRO-COLOIDON (U. S. ARMY) FOR 8″ FIELD GUNS.

Multitubular, colloided. Diameter 13.86 m/m. Clear brown surface, smooth and somewhat translucent. Slight smell.

| | Not Heated. | 3 mos. at 60°C., dry air. | 6 mos. at 60°C., dry air. | 3 mos. at 49°C., moist air. | 6 mos. at 49°C., moist air. |
|---|---|---|---|---|---|
| Physical changes. | | Appearance unchanged; distinct smell of nitrogen peroxide. | A little warped; longitudinal cracks; strong smell of nitrogen peroxide. | Appearance considerably changed. Color faded and opaque; deliquescent white spots; distinct smell of nitrogen peroxide. | Decomposition still more distinct; color almost white; deliquescent and quite decomposed; strong smell of nitrogen peroxide. |
| Reaction with litmus paper | Neutral. | Paper red. | Paper red and partially discolored. | Discolored. | Discolored. |
| Loss of weight %. | 0 | 2.51 | 4.51 | 2.85 | 22.28 |
| Nitrogen % on original material %. | 11.36 | 11.46 | 11.34 | 11.26 | 9.57 |
| On dry material %. | 11.73 | 11.76 | 11.59 | 11.65 | 9.98 |
| Aqueous extract % on original material %. | 1.14 | 1.10 | 2.58 | 1.13 | 1.27 |
| On dry material %. | 1.17 | 1.13 | 2.64 | 1.17 | 1.32 |
| Heat test at 71°C. Minutes. | 32½ | ½ | —— | In the cold. | In the cold. |
| Ignition. | 182.5° | 175.5° | 181.5° | 180° | 180.5° |
| Temperature °C. | 189° | 176° | 182° | 179° | 180° |

INFLUENCE OF MOIST AIR ON THE BALLISTIC QUALITIES.

The following experiments show how greatly the figures given in the heat-test may be lowered while the ballistic properties remain practically the same.

FIRING TEST OF NITRO-CELLULOSE POWDER STORED AT 46°C.

IN MOIST AIR.

| How packed. | Weight of charge k.g. | Temp. of charge °C. | Initial velocity ft. per sec. | Pressure Tons per sq. in. | Heat test at 82°C., min. |
|---|---|---|---|---|---|
| Not heated. | 15.649 | 27° | 2763 | 15.20 | |
| " " | " | 26° | 2720 | 14.35 | 26 |
| " " | " | 26° | 2741 | 14.75 | |
| After 6 mos. In hermetically closed iron. | " | 26° | 2791 | 15.80 | |
| " " " " | " | 26° | 2783 | 15.85 | |
| " " " " | " | 26° | 2768 | 15.50 | 4 |
| " " " " | " | 26° | 2817 | 16.50 | |
| " " " " | " | 26° | 2792 | 15.30 | |
| " " In wood | 15.618 | 27° | 2718 | 15.10 | |
| " " " | 15.645 | 27° | 2725 | 15.10 | |
| " " " | 15.413 | 27° | 2738 | 15.80 | ¾ |
| " " " | 15.411 | 27° | 2702 | 14.90 | |
| " " " | 15.547 | 27° | 2734 | 15.05 | |

When the powder has been freely exposed to moist air its influence on the ballistic properties can be recognized as the following figures show:

| | | | | | |
|---|---|---|---|---|---|
| Not heated. Ordinarily. | 15.649 | 26° | 2741 | 14.75 | |
| After 6 mos. Exposed to moist air. | 15.521 | 26° | 2702 | 14.40 | |
| " " " " | 15.521 | 26° | 2645 | 13.55 | 0¾ |
| " " " " | 15.521 | 26° | 2584 | 13.00 | |
| " " " " | 15.521 | 26° | 2580 | 13.10 | |

## Book Notices.

*A Text-Book of Physics*, edited by A. Wilmer Duff. Contributors: A. Wilmer Duff, Karl E. Guthe, William Hallock, E. Percival Lewis, Arthur W. Goodspeed, Albert P. Carman, R. K. McClung. P. Blakiston's Son & Co., Philadelphia. Cloth, 680 pages, 6 x 8½ inches, 511 illustrations. Price, $2.75 net.

It is scarcely possible with the present-day development of a broad subjest like physics to attain the highest efficiency in the production of a text-book by the unaided effort of a single author. In the preparation of this work an appreciation of the value of concerted effort is evidenced by the

colaboration of seven contributors, each responsible for a distinct division of the subject.

The arrangement of topics follows the usualy accepted order, Mechanics Properties of Matter, Heat, Wave, Motion and Sound, Electricity and Magnetism, Electro-Magnetic Induction, Conduction of Electricity through Gases and Radioactivity. These are treated with a thoroughness consistent with the limitations of a general text-book, elaboration having been avoided without the omission of essentials.

The deductions made are satisfying without being too profound and numerous illustrative problems are given at the end of each chapter. These, particularly, enhance its value as a general text-book. The important matter of an index has not been neglected—an index of names and subjects is given.

The type is clear and cuts well executed. E.

*Internal Combustion Engines*, their Theory, Construction and Operation. By Rolla C. Carpenter, M.M.E., L.L. D., and H. Diedrichs, M.E. D. Van Nostrand Company, New York. xiv, 597 pages, 6¼x9½ inches, with numerous illustrations and tables.

The author's aim has been to develop the subject in a logical order and in the simplest terms possible.

Beginning with classification and definition, thermodynamic principles are discussed and applied, then combustion and fuels and apparatus for their utilization are treated. At this point a historical sketch of the origin and development of the gas engine is given. Then follows a detailed account of the various types of modern engines and their auxiliaries. Methods of power estimation, testing engines and producers and costs are covered in the final chapters. While theoretic principles have been freely considered the work is really only the more practical from the many and related numerical deductions which follow.

The complete and fully illustrated section on types, details and operation of modern engines is valuable even to one seeking general information only. In this the structural features of design are very properly omitted. The chapter on cost data and detailed estimates of cost is an unusual and welcome addition to a treatise of this kind.

The work as a whole is a well arranged treatise which may be safely recommended for a thorough course on this subject. L. E. P.

*Road Preservation and Dust Prevention.* By Wm. Pierson Judson, Consulting Engineer. Engineering News Publishing Company, New York. Cloth, 6 x 9 in., 144 pages, 16 illustrations. Price, $1.50 net.

Dust prevention and road preservation form one of the vexed problems of the day, and a work devoted specifically to the subject should make a welcome addition to the literature of highway engineering.

The conditions producing dust and methods of prevention are first discussed, followed by detailed descriptions of various treatments and methods of their application. These are well illustrated by half-tone cuts.

Numerous references to original sources of information and the unit costs given for each method of treatment are features to be considered.

The subject-matter, well classified under the usual topics discussed, and a copious index enhance its value for reference.

The book is well printed and attractively bound. L.

*Reinforced Concrete.* A Manual of Practice. By Ernest McCullough, M.D., S.E., Civil Engineer, Chicago. Cement Era Publishing Company, 1908. Cloth, 128 pages, 5″ x 8″. Price, $1.00.

Much of the literature on reinforced concrete consists in elaborate treatises from which it is troublesome to formulate rules of practice for commercial use. In the present volume is elaborated such a set of rules of practice from which the non-essentials of the subject have been eliminated, and the author's personal experience introduced. Beams, floors, columns, retaining walls, tanks and footings are treated, and finally, costs, practical details of form and conduct of the work in the field are described at considerable length. The subject matter is thoroughly practical, clearly and forcibly expressed. The work should find a welcome place at the desk of the concrete designer. L. E. P.

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## PUBLICATIONS RECEIVED.

Return of the "Galilee" and construction of a special vessel by L. A. Bauer, director. Reprinted from "Terrestrial Magnetism," Vol. 13, No. 2. 2 pages, 8-vo.

The Earth's Residual Magnetic Field. A Tanakadate; L. A. Bauer. Reprinted from "Terrestrial Magnetism," Vol. 13, No. 2. 5 pages, 8-vo.

Is the Earth's Action on a Magnet only a Couple? (Preliminary report on "Results of Careful Weighings of Magnets in Various Magnetic Fields"), by L. A. Bauer. From "Terrestrial Magnetism and Atmospheric Electricity" for March, 1908. 11 pages, 8-vo.

Some Results of the Magnetic Survey of the United States, by L. A. Bauer. (Reprinted from "Science," N. S., Vol. 27, No. 699, pages 812-816, May 22, 1908.) 5 pages, illustrations, 4to.

Konstant Auftretende Secundäre Maxima und Minima in den Jährlichen Verlauf der Meteorologischen Erscheinungen von Dr. Van Rijckevorsel. Fünfte Abteilung. 14 pages, plates, 4to. Rotterdam, W. J. Van Hengel, 1908.

Bulletin du Laboratorie d'Essais Mecaniques, Physiques, Chimiques et des Machines du Conservatoire National des Arts et Metiers. No. 14. Essais de Torsion Les essais de torsion considérés comme moyens de sélection des métaux. Relations entre la torsion et la traction par Pierre Breuil. 17 pages, illustrations, plates, 8-vo. Paris, Ch. Beranger, 1908.

Palæzoic Rocks Under Southeastern England, by Edward A. Martin, F. G. S. Reprinted from "Knowledge and Scientific News," August, 1908. 11 pages, illustrations, 12-mo. London, King, Sell & Olding, 1908.

United States Department of Agriculture, Forest Service—

Circular 135. Chestnut Oak in the Southern Appalachians, by H. D. Foster and W. W. Ashe. 23 pages, 8-vo.

Circular No. 139. A Primer of Wood Preservation, by W. F. Sherfesee. 15 pages, 8-vo.

Circular No. 151. The Preservative Treatment of Loblolly Pine Cross-Arms, by W. F. Sherfesee. 29 pages, illustrations, 8-vo.

Circular 153. Exports and Imports of Forest Products, 1907, compiled by A. H. Pierson. 26 pages, 8-vo. Washington Gov't Printing Office, 1900.

United States Department of Commerce and Labor, Census Bureau. Forest Products, No. 1. Pulp Wood Consumption, 1907. Compiled in co-operation with the Department of Agriculture, Forest Service. 14 pages, 8-vo. Washington Gov't Printing Office, 1908.

How to Build Up Furnace Efficiency, by Jos. W. Hays. Unpaged, 16-mo. Chicago, author, 1908, paper. Price, 50 cents.

Pennsylvania State College, Annual Report for the year 1906-1907. Part I, Department of Instruction. Part II, Agricultural Experiment Station. Harrisburg, State Printer, 1908.

Georgia Geological Survey, Bulletin No. 16. Second Report on the Water Powers of Georgia, by B. M. Hall and M. R. Hall. 424 pages, illustrations, plates, maps, 8-vo. Atlanta, Franklin-Turner Co., 1908.

Bulletin No. 17. Report on the Fossil Iron Ores of Georgia, by S. W. McCallie. 199 pages, illustrations, plates, maps, 8-vo. Atlanta, Franklin-Turner Co., 1908.

Pennsylvania State College Bulletin, Vol. II, No. 4, June, 1908. Proceedings of the Forty-eighth Annual Commencement and the Inauguration of Edwin Erle Sparks, Ph.D., as President of the Pennsylvania State College, June 17, 1908. 128 pages 8-vo. State College, 1908.

International Acetylene Association, Eleventh Annual Meeting, held at Auditorium Hotel, Chicago, August 10, 11, 12, 1908. 171 pages, illustrations, 8-vo. Chicago, Secretary-Treasurer, n. d.

Ontario Bureau of Mines. Report, 1907, Vol. 16, Part II. The Cobalt-Nickel Arsenides and Silver Deposits of Temiskaming (third edition), by Willet G. Miller, Provincial Geologist. 212 pages, illustrations, maps, 8-vo. Toronto, King's printer.

Thoughts on Natural Philosophy with a new reading of Newton's First Law, by A. Biddlecombe. 24 pages, 16-mo. London, Whittaker & Co., n. d.

A history of the Origin of the Place Names in nine Northwestern States, including States, Counties, Towns, Villages and Stations connected with the Chicago and Northwestern and Chicago, St. Paul, Minneapolis and Omaha Railways. Ed. 2. Compiled by one who for more than thirty-four years has been an officer in the employ of the company. 201 pages, map, 8-vo. Chicago, 1908.

Michigan State Board of Health, thirty-fifth Annual Report of the Secretary for the year ending June 30, 1907. 188 pages, 8-vo. Lansing, State Printers, 1908.